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CONTENTS

The cephalopod fauna of the Pennsylvanian Union Valley formation of Oklahoma ..... *A. K. Miller and John Britts Owen* 417

Cretaceous, Tertiary, and recent corals, a sponge, and an alga from Venezuela ..... *John W. Wells* 429

Ostracoda from the Reklaw Eocene of Bastrop County, Texas ..... *Morton B. Stephenson* 448

Permian trilobites from Western Australia ..... *Curt Teichert* 455

A new Paleocene gastropod from southern California ..... *Robert R. Compton* 464

The auditory region in some Miocene carnivores ..... *Margaret Jean Hough* 470

PALEONTOLOGICAL NOTES

Corrections for a "Check list of the fossil reptiles of New Jersey" ..... *Edwin H. Colbert* 480

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VOLUME 18 SEPTEMBER, 1944 NUMBER 5

THE CEPHALOPOD FAUNA OF THE PENNSYLVANIAN UNION VALLEY FORMATION OF OKLAHOMA

A. K. MILLER AND JOHN BRITTS OWEN
Iowa City, Iowa, and Clinton, Missouri

ABSTRACT—Representatives of six cephalopod genera are illustrated and described from the Union Valley formation of south-central Oklahoma: *Mooreoceras?*, *Liroceras*, *Pronorites*, *Cravenoceras?*, *Gastrioceras*, and *Eoasianites*. It is concluded that the fauna is early Pennsylvanian in age and is very closely related to that of the Hale formation (Morrow) of northwestern Arkansas.

Also, there is included in this report a study of representatives of *Pseudoparalegoceras* and *Goniolobоceras* from nearby outcrops of the underlying "Pennsylvanian Caney" shale. These are not closely related to Union Valley forms.

THE NAME Union Valley was proposed by Hollingsworth in 1933 for the petroleum-producing sandstone of south-central Oklahoma which lies conformably on the so-called "Pennsylvanian Caney" shale and which is overlain disconformably by the Wapanucka formation. In oil field terminology this sandstone has been called the "Cromwell," "Lyons-Quinn," "Papoose," "Ingram," "Smith," and "Sykes," but none of these names seems to have been established—the first, however, is well known. At the type locality, on the Lawrence Uplift near the Union Valley schoolhouse in the SW¼ sec. 28, T. 3 N., R. 7 E. Pontotoc County, Oklahoma, the Union Valley is stated to consist of "light-brown, massive to thin-bedded, coarse to fine-grained sandstones, with a maximum thickness of 242 feet."

Hollingsworth regarded the Union Valley sandstone as a member of the Wapanucka formation, but in 1936 Hyatt raised it to the rank of a formation. He states that it "normally consists of two members: a lower sandstone member 100 feet thick, and an upper limestone member 50 feet thick." The limestone is "blue shaly, sandy, and glauconitic," and locally it is separated from the underlying sandstone by some 10–15 feet of shale. According to Hollingsworth, at the type locality this limestone is only 4 to 6 feet thick.

Lists published by Morgan and by Hollingsworth indicate that the upper or limestone member of the Union Valley formation carries an abundant and diversified fauna including foraminifers, brachiopods, pelecypods, gastropods, cephalopods, trilobites, and conodonts. The latter author concludes that the assemblage is "a Morrow fauna of Brentwood affinities" and that the microfauna is "similar to that described by Harlton from the Johns Valley shale of the Oklahoma Ouachitas."

Our work has been confined to the cephalopods, and the collections we are studying came from outcrops of the upper or arenaceous limestone portion of the Union Valley along Buck Creek just north of the Midland Valley Railroad near Lovelady in the SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma. This is almost certainly the same as Morgan's locality 170, from which he (1924, p. 55) lists several species of corals, brachiopods, pelecypods, gastropods, and cephalopods. Ammonoids are far more

abundant than any of the other forms here, though they are rare elsewhere in the Union Valley. It should perhaps be mentioned that a transverse break across one of the specimens we are studying exposes a camera lined with inwardly projecting crystals of calcite and filled with black viscous petroleum.

Three species of cephalopods are very abundant in the limestone member of the Union Valley: *Cravenoceras? morrowense*, *Glaphyrites oblatus*, and *Gastrioceras grileyi*. The first two of these are also the most abundant cephalopods in the Hale formation of northwestern Arkansas, and the third is close to *Gastrioceras branneri halense*, another abundant Hale form. Furthermore, the Hale and the Union Valley have other cephalopods in common: *Pronorites arkansasensis*, *Gastrioceras branneri branneri*, *Liroceras* cf. *L. liratum*, and *Mooreoceras?* sp. A direct comparison with the Hale specimens described by Miller and Moore in 1938 has convinced us that the similarity is genuine. In summary, it can be said that all nine of the species of cephalopods known from the Union Valley are congeneric with Hale forms, and at least five or six of them are conspecific. These facts lead us inescapably to the conclusion that the upper or limestone member of the Union Valley formation should be correlated with the cephalopod-bearing portion of the Hale formation. Hollingsworth has recently (June 8, 1944) written us that on the basis of both lithological and faunal evidence he also correlates the Union Valley and the Hale.

It should also be mentioned that the collections under consideration contain a few goniatites from limonite concretions in the so-called "Pennsylvanian Caney" shale along a small stream in sec. 8, T. 2 N., R. 7 E., northwest of Frisco, Pontotoc County, Oklahoma. This locality is some 3½ miles south of the outcrops that yielded the Union Valley cephalopods. These "Pennsylvanian Caney" specimens are referable to two species, *Pseudoparalegoceras friscoense* and *Goniolobocerasp.* Neither of them is closely related to the forms that occur in the Union Valley. However, the first is somewhat similar to species known from the Morrow of Arkansas and the Bend of Texas; and it is worthy of note that the second is probably the oldest known representative of *Goniolobocerasp.*

Much of the material on which our report is based was collected in 1933 and 1934 by the junior author with the aid of H. L. Griley and the late John Fitts. Another large collection was assembled by L. M. Cline and placed at our disposal. Also, we wish to acknowledge our indebtedness to A. G. Unklesbay, Howard Webster, and Wendy Robb for aid in the preparation of the illustrations which accompany this report; to R. V. Hollingsworth and H. L. Griley for information and advice in regard to the nature of the Union Valley sandstone and the "Pennsylvanian Caney" formations and their faunas; and to the Graduate College of the State University of Iowa which made the preparation of the report financially possible.

SYSTEMATIC PALEONTOLOGY

Genus MOOREOCERAS Miller, Dunbar, and Condra, 1933

MOOREOCERAS? sp.

Plate 63, figure 5

Aside from one small fragment, only a single straight nautiloid is contained in the rather extensive collections of Union Valley cephalopods that are available for study. This specimen is about 90 mm. long, and at least all but the adoral 12 mm. of it represent phragmacone. The conch has been crushed during preservation, and it may have been circular or broadly elliptical in cross section. Near its midlength, the specimen, in its present distorted state, is about 20 mm. wide and about 14 mm. high.

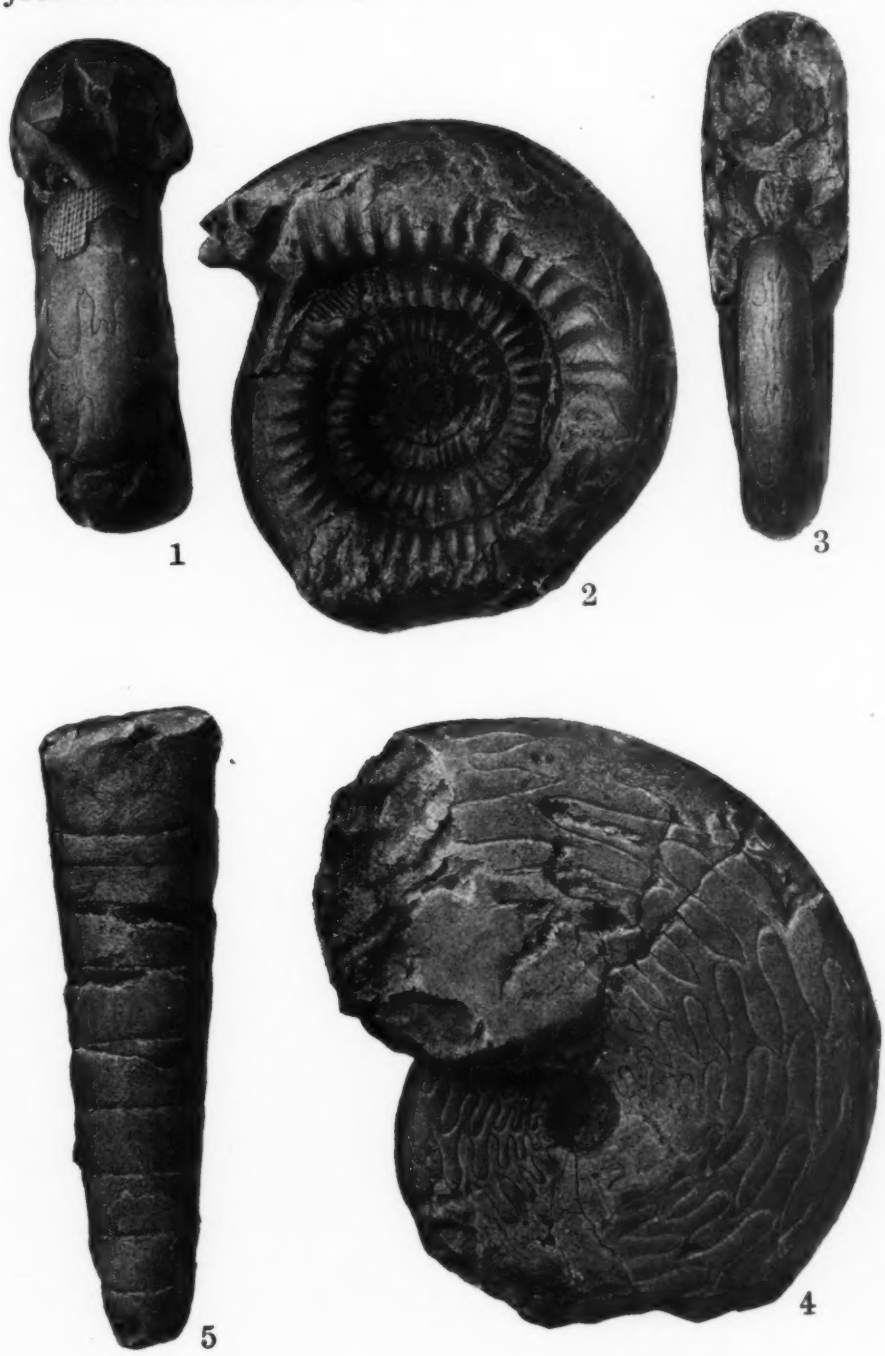
EXPLANATION OF PLATE 63

All specimens illustrated on this plate are from the upper part of the Union Valley formation near Lovelady in SE ¼ NE ¼ NE ¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma; and all figures are ×1.

FIGS. *1, 2—Gastrioceras branneri branneri* Smith. Ventral and lateral views of a large septate specimen. (p. 422)

3, 4—Pronorites arkansasensis Smith. Two views of a moderately well preserved large phragmacone—figure *3* represents all but the adoral quarter-volution of figure *4*. (p. 420)

5—Mooreoceras sp. A specimen that has been somewhat crushed and distorted. (p. 418)



Miller and Owen, Pennsylvanian Cephalopods

Miller and Owen, Pennsylvanian Cephalopods

The internal mold is essentially smooth, but there are fine transverse lirae on a fragment of the test which adheres to the specimen under consideration. These lirae may, however, have been on an inner layer of the test, rather than on the surface of it. The portion of them that is preserved is straight and directly transverse and is parallel to the sutures. The camerae are rather long, and throughout the specimen their length averages about 9 mm.

A structure that appears to represent the siphuncle is central or nearly so in position and is rather small. At a transverse break along a septum near the midlength of the specimen, this structure is only some 2.5 mm. in diameter.

Remarks.—The structure of the siphuncle of this form can not be ascertained from the available material, and therefore its generic affinities can not be determined with certainty. In general physiognomy it resembles *Mooreoceras*, to which genus it is being referred with question. Its long camerae, which distinguish it from known representatives of *Mooreoceras*, seem to be one of its most distinctive characters. Presumably this specimen represents an unnamed species, but it would not make a satisfactory holotype as its internal structures are so poorly preserved.

Occurrence.—Impure arenaceous limestone at top of Union Valley formation along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma.

Repository.—John Britts Owen collection at State University of Iowa, 13938.

Genus LIROCERAS Teichert, 1940
LIROCERAS cf. L. LIRATUM (Girty)
Plate 64, figures 1–3

The Union Valley formation has yielded three moderately well preserved but somewhat crushed specimens that seem to resemble the genotype of *Liroceras* rather closely and may be conspecific with it. The largest of these (pl. 64, fig. 3) is about 62 mm. in diameter. The adoral two-fifths of the outer volution of this specimen represents living chamber, near the midlength of which the conch is some 43 mm. wide and 24 mm. high. Corresponding measurements at the junction of the phragmacone and the living chamber are about 34 mm. and 20 mm., respectively. These figures make it clear that the conch is expanded orad fairly rapidly. The cross section is reniform as the conch is broadly rounded ventrally, narrowly rounded laterally, and impressed dorsally.

Faint traces of growth lines on the specimen represented by figures 1 and 2 on plate 64 show that the conch bears a prominent very narrowly rounded hyponomic sinus. Fragments of the test that adhere to the umbilical wall of the specimen represented by figure 3 on the same plate show that at least the adoral part of the phragmacone of that specimen bears large prominent longitudinal lirae and more numerous finer transverse lirae.

The camerae are moderately long, and the length of the adoral camera of the larger of the figured specimens measures about 7.5 mm. along the venter. The external sutures are directly transverse and essentially straight, though they appear to form very slight ventral lobes. The internal sutures form a fairly deep rounded dorsal lobe, in the center of which is a small but prominent V-shaped annular lobe. The siphuncle is subcentral, small, and orthochoanitic in structure. Where the conch is about 30 mm. wide, the diameter of the siphuncle is only about 1.5 mm.

Remarks.—All three of the specimens under consideration are somewhat crushed and distorted, and therefore it is not possible to determine the precise shape of the conch. In general physiognomy it resembles typical *Liroceras liratum*, but its lateral zones seem to be more narrowly rounded. *L. liratum* ranges through much of the Pennsylvanian

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EXPLANATION OF PLATE 64

All specimens illustrated on this plate are from the upper part of the Union Valley formation near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma; and all figures are ×1.

FIGS. *1–3*—*Liroceras* sp. Two views of one specimen, and one of another. (p. 419)

4–6—*Gastrioceras adaense* Miller and Owen, n. sp. *4*, Ventral view of a paratype; *5*, *6*, two views of the holotype. (p. 423)

system in Kansas, Oklahoma, and Texas.

Occurrence.—Impure arenaceous limestone at top of Union Valley formation along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma. Specimens that appear to be conspecific (State Univ. Iowa, 13941) have been collected from the Brentwood limestone member of the Bloyd formation (Morrow group) in sec. 9, T. 15 N., R. 24 E., Adair County, Oklahoma.

Repository.—John Britts Owen collection at State University of Iowa, 13939 (figured specimens) and 13940.

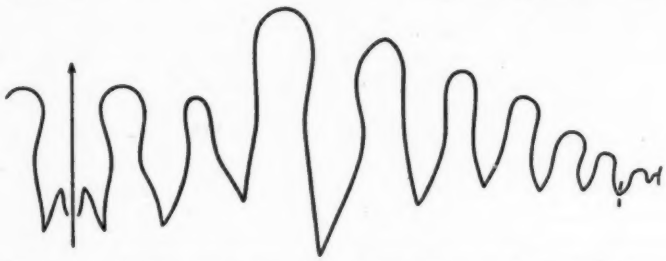


FIG. 1—Diagrammatic representation of a mature suture of *Pronorites arkansasensis* Smith where the conch is about 40 mm. high. ×2.

Genus PRONORITES Mojsisovics, 1882

PRONORITES ARKANSASENSIS Smith

Plate 63, figures 3, 4; text fig. 1

Goniatites cyclolobus WILLIAMS [not Phillips], 1900, Arkansas Geol. Survey, Ann. Rept. 1892, vol. 5, p. 359.

Pronorites cyclolobus arkansasensis SMITH, 1896, Am. Philos. Soc. Proc., vol. 35, pp. 267–270, pl. 24, figs. 1–4; 1897, Leland Stanford Junior Univ. Pub., pp. 57–60, pl. 24, figs. 1–4; 1903, U. S. Geol. Survey Mon. 42, pp. 43–46, pl. 12, figs. 12–15; 1914, Leland Stanford Junior Univ. Pub., Univ. ser., pl. 12, figs. 11, 12.

Pronorites arkansasensis, SMITH, 1913, Zittel-Eastman Textbook of Paleontology, vol. 1, ed. 2, p. 633, text fig. 1183.—MILLER, 1930, Jour. Paleontology, vol. 4, p. 394.—PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 57–59, pl. 2, figs. 1–4.—MILLER and MOORE, 1938, Jour. Paleontology, vol. 12, pp. 345–346, pl. 43, figs. 8, 9.

Three representatives of *Pronorites* are known from the Union Valley sandstone, and all of them seem to be referable to *P. arkansasensis*. The largest (pl. 63, figs. 3, 4) is about 95 mm. in diameter, and it is septate throughout. The preserved portion of this specimen attains a maximum width of about 25 mm. and a corresponding height of conch of about 52 mm. On the ventrolateral and ventral portions of one of the unfigured specimens there are traces of low rounded ribs, which form broad rounded ventral salients. Where the conch is about 28 mm. high, these ribs are some 2 mm. apart.

Our diagrammatic representation of a suture (text fig. 1) and those published by Smith differ in certain details. However, the differences are largely matters of interpretation and are more apparent than real.

Remarks.—Both of the unfigured specimens in the collections under consideration are septate throughout, and both are smaller than the figured specimen. A direct comparison of these Union Valley specimens with those described by Miller and Moore from the Morrow group indicates clearly that all are conspecific.

Certain of the Pennsylvanian pronoritids had distinct ventral ribs on their conchs, and they are now referred to *Stenopronorites*. The incipient ribs on one of the specimens under consideration indicate gradation between typical *Pronorites* and typical *Stenopronorites*.

Occurrence.—The specimens we are studying came from an impure arenaceous limestone at the top of the Union Valley formation along Buck Creek just north of the Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N. R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma. Conspecific specimens have been recorded from the Hale formation (lower Morrow) of northwestern Arkansas and the Smithwick shale (Bend) of central Texas.

Repository.—John Britts Owen collection at State University of Iowa, 13942 (figured specimen), 13943, and 13944.

Genus CRAVENOCERAS Bisat, 1928
CRAVENOCERAS? MORROWENSE Miller and Moore
Plate 65, figures 3, 4; plate 66, figures 3, 4; text fig. 2B

Cravenoceras? morrowense MILLER and MOORE, 1938, Jour. Paleontology, vol. 12, pp. 346–347, pl. 43, figs. 1–3.

All 20 of the representatives of this species in the collections we are studying are septate throughout. The largest of them (pl. 65, figs. 3, 4) is about 73 mm. in diameter. Near the adoral end of this specimen the conch is about 38 mm. wide and about 33 mm. high, and the impressed zone is about 15 mm. deep. At this place the diameter of the umbilicus measures about 14 mm. The umbilical shoulders are abrupt, and the umbilical walls, though distinctly convex exteriorly, are almost vertical. Most of the other conspecific specimens known from the Union Valley are from 35 to 50 mm. in diameter, and all of them are very much alike. None retains the test or any trace of the growth lines. However, several of them show that the internal mold bears faint rounded transverse constrictions, which are very slightly sinuous. There seems to be about five of these constrictions to the volution.

The shape of the sutures at maturity is shown by text figure 2B. Throughout ontogenetic development the lobes of the sutures become more acuminate and the saddles more narrowly rounded. The internal sutures consist of a deep pointed spatulate dorsal lobe and on either side of it a high rounded saddle, which is constricted near its midheight, a somewhat shorter pointed spatulate lateral lobe, and a rather low broad asymmetrical rounded saddle, which extends to the lobe on the umbilical wall.

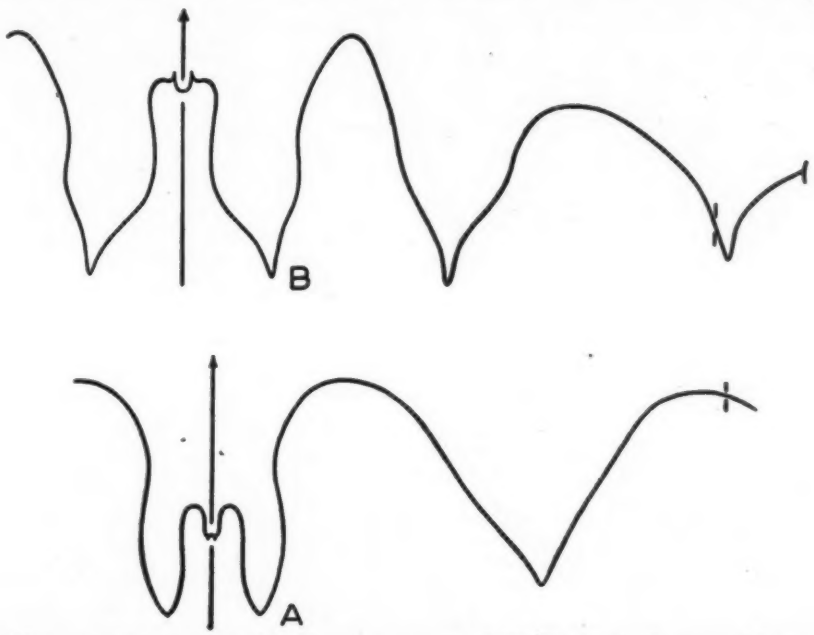


FIG. 2—Diagrammatic representation of mature sutures of (A) *Pseudoparalegoceras friscoense* Miller and Owen, n. sp., where the conch is about 7½ mm. high, ×7½; and (B) *Cravenoceras? morrowense* Miller and Moore where the conch is about 22 mm. high, ×2½.

Remarks.—The type specimens of this species, which came from the Morrow group, are available to us for study. A direct comparison of them with the Union Valley specimens makes it clear that all are very closely similar and presumably conspecific. *C.? richardsonianum* (Girty) of the Caney shale of southeastern Oklahoma and the Barnett shale of central Texas is also quite similar, but its conch is more broadly rounded ventrally and the ventral lobe of its sutures is

somewhat broader. As pointed out by Miller and Moore, these two species seem to be more or less intermediate between forms that are regarded as typical of *Homoceras* and those that are regarded as typical of *Cravenoceras*. However, uncertainty exists as to the nature of the genotype of *Homoceras* at maturity, and therefore we are referring these species with question to *Cravenoceras* rather than to *Homoceras*.

Occurrence.—Abundant in impure arenaceous limestone at top of Union Valley sandstone along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma. This species occurs also in the Morrow group of northwestern Arkansas and northeastern Oklahoma.

Repository.—John Britts Owen collection at State University of Iowa, 13947 (pl. 4, figs. 3, 4), 13948 (pl. 3, figs. 3, 4), 13949, and 13950.

Genus GASTRIOCERAS Hyatt, 1884

GASTRIOCERAS BRANNERI BRANNERI Smith

Plate 63, figures 1, 2; plate 65, figures 1, 2; text fig. 3C

Gastrioceras branneri SMITH, 1896, Am. Philos. Soc. Proc., vol. 35, pp. 257–258, pl. 23, figs. 1–6; 1897, Leland Stanford Junior Univ. Pub., pp. 47–48, pl. 23, figs. 1–6; 1903, U. S. Geol. Survey Mon. 42, pp. 83, 84, pl. 11, figs. 8–13; 1914, Leland Stanford Junior Univ. Pub., Univ. ser., pl. 1, figs. 12–14.—MATHER, 1915, Denison Univ. Bull., Jour. Sci. Labs., vol. 18, p. 242, pl. 16, figs. 12, 12a.—CRONEIS, 1930, Arkansas Geol. Survey Bull. 3, p. 81.

Goniatites branneri WILLIAMS, 1900, Arkansas Geol. Survey Ann. Rept. 1892, vol. 5, p. 359.

Branneroceras branneri PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 218–221, pl. 11, figs. 1–7.

Branneroceras branneri branneri MILLER and MOORE, 1938, Jour. Paleontology, vol. 12, pp. 348–350, pl. 44, figs. 5–12.

Several moderately well preserved specimens in the available collections from the Union Valley sandstone are strikingly similar to typical representatives of *Gastrioceras branneri* from the Morrow group. They show the same gradually expanding conch, large umbilicus, reticulate test, and prominent lateral ribs and umbilical nodes formed by the growth lines becoming fasciculate. These specimens supplement each other very well, for some of them retain the test (or a replacement of it) and others are internal molds. Collectively they elucidate most of the significant characters of the species.

Our study of these specimens enables us to substantiate the detailed description published by Miller and Moore in 1938, but they do not permit us to add to it materially. The largest of the Union Valley specimens attains a diameter of about 78 mm., and the adoral quarter-volution of this specimen represents living chamber. Another large Union Valley specimen (pl. 63, figs. 1, 2) is more than 70 mm. in diameter, and it is septate throughout. The shape of the adoral sutures of this latter specimen is show by text figure 3C.

Remarks.—G. A. Cooper of the U. S. National Museum recently loaned us for study the largest known representative of this species (pl. 65, figs. 1, 2). This specimen came from the Morrow group of northeastern Oklahoma. The preserved part of it attained a diameter of more than 80 mm., and it is septate throughout and therefore represents only phragmacone. Like many of the other Morrow specimens, this one retains the test, and it shows that on the adoral portions of large individuals the lateral ribs and umbilical nodes decrease in prominence, but the reticulate ornamentation on the ventral zone of the conch continues unabated.

In 1937 Plummer and Scott proposed the generic name *Branneroceras* for

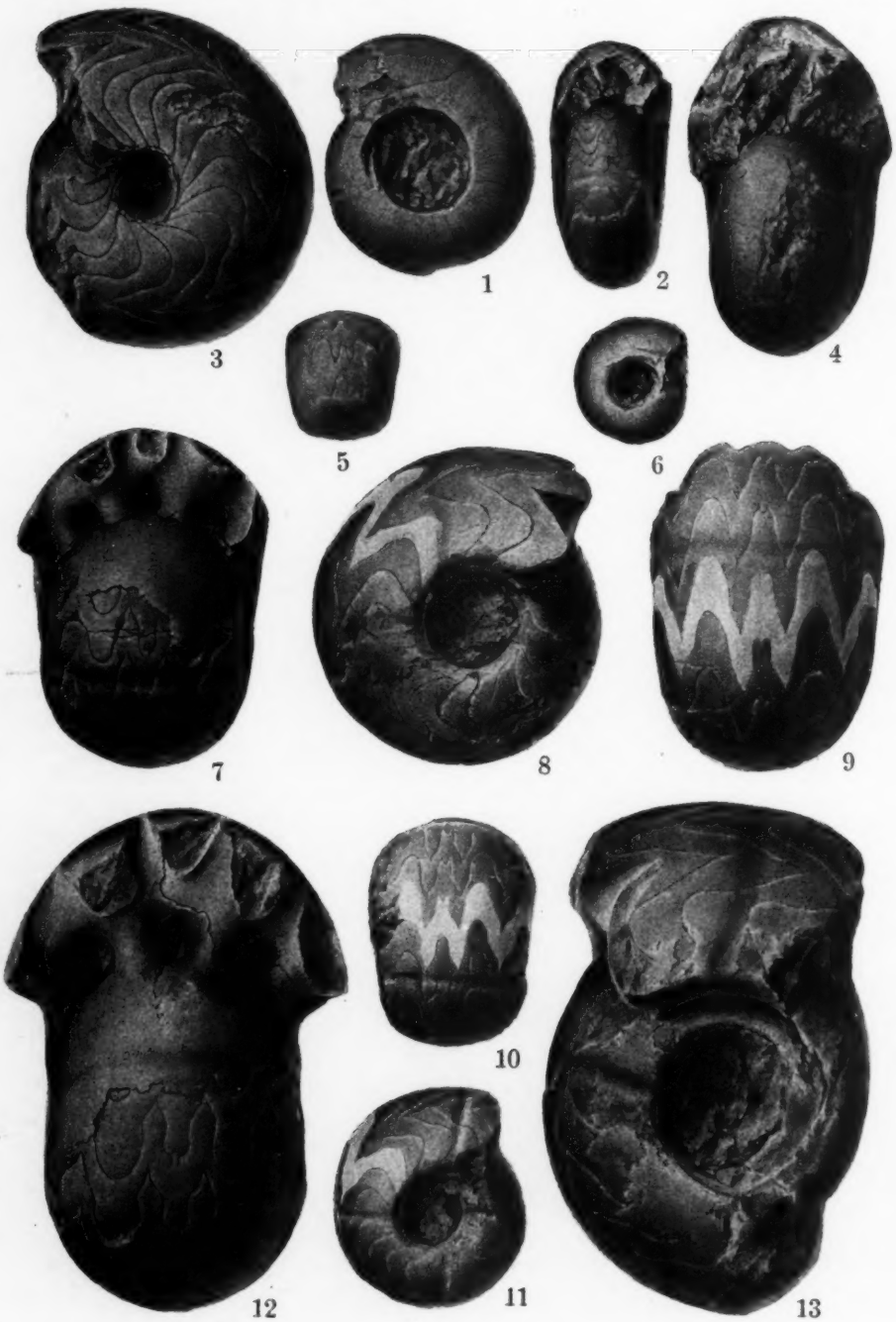
> evolute ammonites having nearly ellipsoidal [elliptical] cross sections, sides that are sculptured with prominent transverse ridges and a suture line which is like that of *Gastrioceras*. The type is *Gastrioceras branneri* Smith.

EXPLANATION OF PLATE 65

FIGS. *1, 2*—*Gastrioceras branneri branneri* Smith. Ventral and lateral views of a large specimen from the Morrow group in the Keough quarry, about 2½ miles north of Ft. Gibson, Oklahoma, ×1. (p. 422)

3, 4—*Cravenoceras? morrowense* Miller and Moore. Two views of the largest representative of this species known, from the upper part of the Union Valley formation near Lovelady about 7 miles southeast of Ada, Oklahoma, ×1. (p. 421)

Miller and Owen, Pennsylvanian Cephalopods



Miller and Owen, Pennsylvanian Cephalopods

However, the genotype of *Gastrioceras*, *G. listeri* (Martin), shows all of these characters except the cross section, which we do not regard as of generic value. Accordingly we are suppressing *Brannerоceras* as a synonym of *Gastrioceras*, which has priority.

Occurrence.—Impure arenaceous limestone at top of Union Valley formation along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma. This variety occurs also in the Morrow group of northwestern Arkansas and northeastern Oklahoma, and probably in the Bend group of central Texas.

Repository.—John Britts Owen collection at State University of Iowa, 13953 (pl. 63, figs. 1, 2), 13954, and 13955; and U. S. National Museum (pl. 65, figs. 1, 2). The specimens at the State University of Iowa are from the Union Valley formation, whereas that at the U. S. National Museum is from the Morrow group.

GASTRIOCERAS ADAENSE Miller and Owen, n. sp.

Plate 64, figures 4–6; text fig. 3A

One of the 10 specimens on which we are basing this species is much better preserved than the others, and it is being designated as the holotype (pl. 64, figs. 5, 6). All of the type specimens are septate throughout and therefore represent only phragmacone. The holotype attains a maximum diameter of about 98 mm., and near its adoral end its conch is about 35 mm. high and about 37 mm. wide. The whorls are flattened laterally, narrowly rounded ventrally, and impressed dorsally. The umbilical shoulders are very abrupt, and the umbilical walls are essentially straight and almost perpendicular to the adjacent portion of the flattened lateral zones. The diameter of the umbilicus at full maturity is equal to about two-fifths that of the conch, and the umbilicus of the holotype attains a maximum diameter of about 38 mm.

The umbilical shoulders bear a single row of moderately small umbilical nodes. These are very distinct on the internal mold, and presumably they are quite prominent on the exterior of the test.

As shown by text figure 3A, the external suture consists of a deeply divided ventral lobe with narrow V-shaped prongs, a U-shaped first lateral saddle, a V-shaped first lateral lobe, an asymmetrical rounded second lateral saddle, and an acuminate lobe on the umbilical wall. The precise shape of the internal sutures is not known, but they consist of a long pointed dorsal lobe and on either side of it a deep narrow saddle, a pointed lateral lobe, and a broad saddle that extends to the lobe on the umbilical wall.

Remarks.—The narrow conch and relatively small umbilicus distinguished this species from all known representatives of the genus except *G. branneri halense* (Miller and Moore) of the Morrow group of northwestern Arkansas. The largest known representative of that form is only about 39 mm. in diameter, and in general physiognomy it does not resemble *G. adaense* very closely.

Occurrence.—Impure arenaceous limestone at top of Union Valley formation along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma.

Repository.—John Britts Owen collection at State University of Iowa, 13956 (holotype), 13957 (figured paratype), and 13958 (unfigured paratypes).

EXPLANATION OF PLATE 66

With the exception of figures *1*, *2*, all specimens illustrated on this plate are from the upper part of the Union Valley formation near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma. The specimen represented by figures *1*, *2* is from the "Pennsylvanian Caney" shale in sec. 8, T. 2 N., R. 7 E., northwest of Frisco, Pontotoc County, Oklahoma. All figures are ×1.

FIGS. *1*, *2*—*Pseudoparalegoceras friscoense* Miller and Owen, n. sp. Lateral and ventral views of the holotype. (p. 427)

3, *4*—*Cravenoceras? morrowense* Miller and Moore. Lateral and ventral views of a typical specimen. (p. 421)

5–13—*Eoasianites oblatus* (Miller and Moore). Two views of each of three specimens, and three views (figs. *7–9*) of another. (p. 425)

GASTRIOCERAS FITTSI
Miller and Owen, n. sp.
Plate 68, figures 1, 2

The holotype, the only known representative of this species, is a large internal mold that is moderately well preserved and appears to be septate throughout. The part of the conch that it represents attained a maximum diameter of at least 200 mm. and a maximum height and width of conch of some 60 mm. and 150 mm., respectively. The volutions are relatively low and broad and are helmet-shaped in cross section. The conch is broadly rounded ventrally and is rather deeply impressed dorsally. The umbilical shoulders are abrupt, and the umbilical walls are almost straight and are fairly steep. The diameter of the umbilicus is equal to about three-fifths that of the conch.

On the outer volution of the holotype, the umbilical shoulders are worn and broken. With the possible exception of this outer volution, there is a single row of rather prominent rounded nodes on each shoulder. There are low continuations of these nodes on the lateral zones of the specimen, and presumably both the nodes and the lateral continuations were much more prominent on the exterior of the test than on the internal mold.

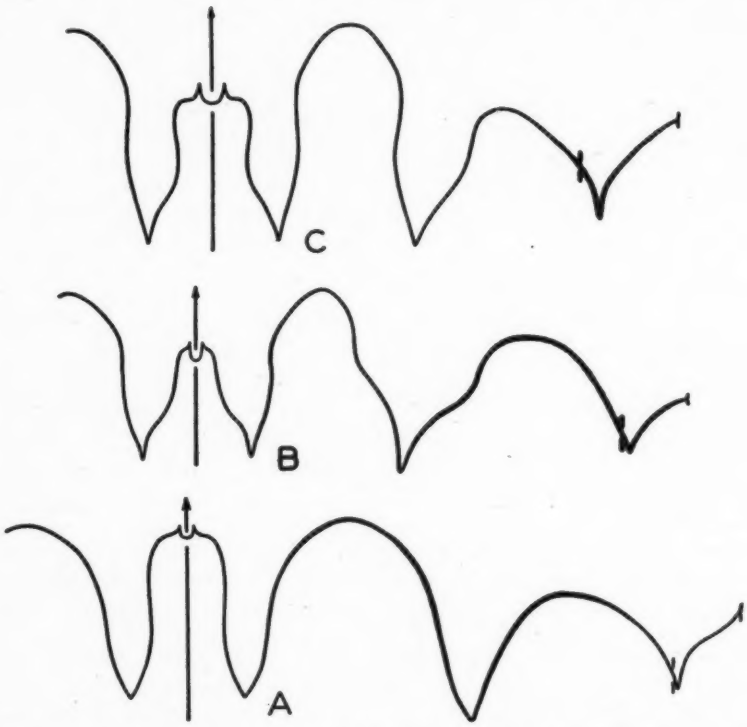


FIG. 3—Diagrammatic representations of mature sutures of (A) the holotype of *Gastrioceras adaense* Miller and Owen, n. sp., at a diameter of about 95 mm., ×1½; (B) the early mature hypotype of *Eoasianites oblatus* (Miller and Moore) represented by figures 10 and 11 on plate 66 at a diameter of about 30 mm., ×3½; and (C) the hypotype of *Gastrioceras branneri branneri* Smith represented by figures 1 and 2 on plate 63 at a diameter of about 70 mm., ×2.

Each external suture consists of a prominently divided ventral lobe with narrow hastate prongs, and on either side of it a deep, broad U-shaped first lateral saddle, a pointed V-shaped first lateral lobe, a broad asymmetrically rounded lobe on the umbilical shoulder, and a pointed lobe on the umbilical wall. The shape of the internal

sutures can not be ascertained from the available material, but presumably they are like those of other gastrioceratoids.

Remarks.—One of the most distinctive characters of this species is, to be sure, the very large size of its conch. Aside from size, it resembles rather closely *Gastrioceras grileyi*, with which it occurs in association. The umbilical nodes on the internal mold distinguish it from such other large Pennsylvanian forms as *Eoasiananites excelsum* (Meek).

Occurrence.—Impure arenaceous limestone at top of Union Valley formation along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma.

Holotype.—John Britts Owen collection at State University of Iowa, 13959.

GASTRIOCERAS GRILEYI
Miller and Owen, n. sp.
Plate 67, figures 4–8; text fig. 4

Gastrioceras listeri MORGAN, 1924, [Oklahoma] Bur. Geology Bull. 2, p. 55.—HOLLINGSWORTH, 1933, Geol. Soc. Am. Proc. for 1933, p. 364.

This species is the most abundant cephalopod in the Union Valley sandstone, and altogether the available collections contain 23 representatives of it. The best of these (pl. 67, figs. 6–8) is being chosen as the holotype. It is a well-preserved internal mold that is septate throughout and therefore represents only phragmacone. The maximum diameter of this specimen measures about 80 mm., and near its adoral end its conch is about 27 mm. high and about 58 mm. wide; corresponding measurements at the adoral end of the penultimate volution are about 18 mm., and 31 mm., respectively. The largest of the paratypes attains a maximum diameter of about 110 mm., and it also is septate throughout.

The early volutions of the conch are relatively wider than the later ones, as is clear from a comparison of figures 5 and 6 on plate 67 with figures 6–8 on the same plate. The innermost volutions are still wider, and where the conch is about 18 mm. in diameter, the whorls are about 16 mm. wide.

The diameter of the umbilicus is equal to about half that of the conch, and the maximum diameter of the umbilicus of the holotype is about 40 mm. The umbilical shoulders bear a row of prominent nodes, which on the internal mold are extended laterally as low ribs. Presumably these nodes and ribs are much more prominent on the exterior of the test than on the internal mold. They seem to become somewhat less prominent during later growth stages. On at least the inner volutions of the conch there are also low rounded transverse constrictions in the internal mold. There are about three of these to the volution, and they are very slightly sinuous.

As shown by text figure 4, the external sutures consist of a broad prominently divided ventral lobe and on either side of it a broad, deep U-shaped first lateral saddle, a V-shaped first lateral lobe, a rounded asymmetrical saddle on the umbilical shoulder, and a low V-shaped lobe on the umbilical wall. From early to late maturity the shape of the external sutures changes relatively little, but the first lateral lobes seem to become somewhat wider and to develop sinuous flanks. The internal sutures consist of three pointed lobes and four rounded saddles; the outer saddles extend to the lobes on the umbilical walls.

Remarks.—This form is readily distinguished from typical representatives of *Gastrioceras branneri* Smith by its relatively wide whorls and narrow umbilicus. It is perhaps closest to *G. fittsi*, n. sp., which is a much larger form with a somewhat larger umbilicus.

Occurrence.—Impure arenaceous limestone at top of Union Valley formation along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma.

Repository.—John Britts Owen collection at State University of Iowa, 13960 (holotype), 13961 (pl. 67, figs. 4, 5), 13962 (text fig. 4A), 13963, and 13964.

Genus EOASIANITES Ruzhencev, 1933

EOASIANITES OBLATUS
(Miller and Moore)
Plate 66, figures 5–13, text fig. 4C

Gastrioceras kansasense MORGAN, 1924, [Oklahoma] Bur. Geology Bull. 2, p. 55.

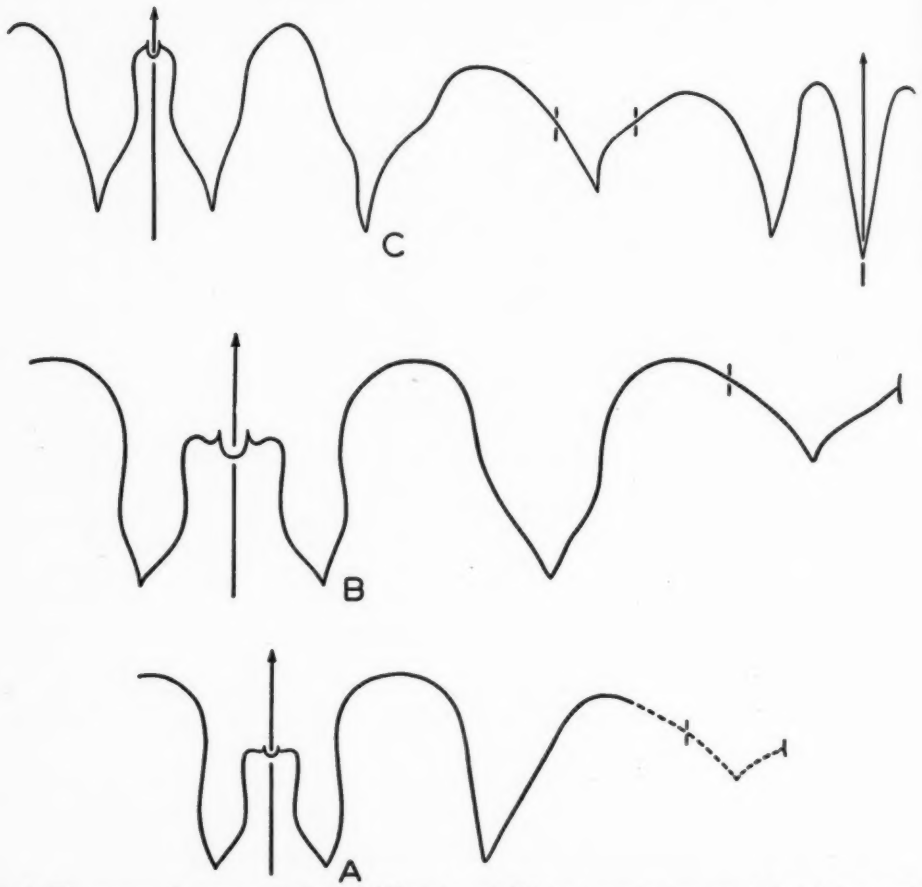


FIG. 4—Diagrammatic representations of (A) early and (B) late mature sutures of *Gastrioceras grileyi* Miller and Owen, n. sp., at diameters of about 40 mm. and 65 mm., respectively; the first is ×3; the latter, which is based on the holotype, is ×2; and (C) a mature suture of *Eoasianites oblatus* Miller and Moore where the conch is about 25 mm. high, ×2.

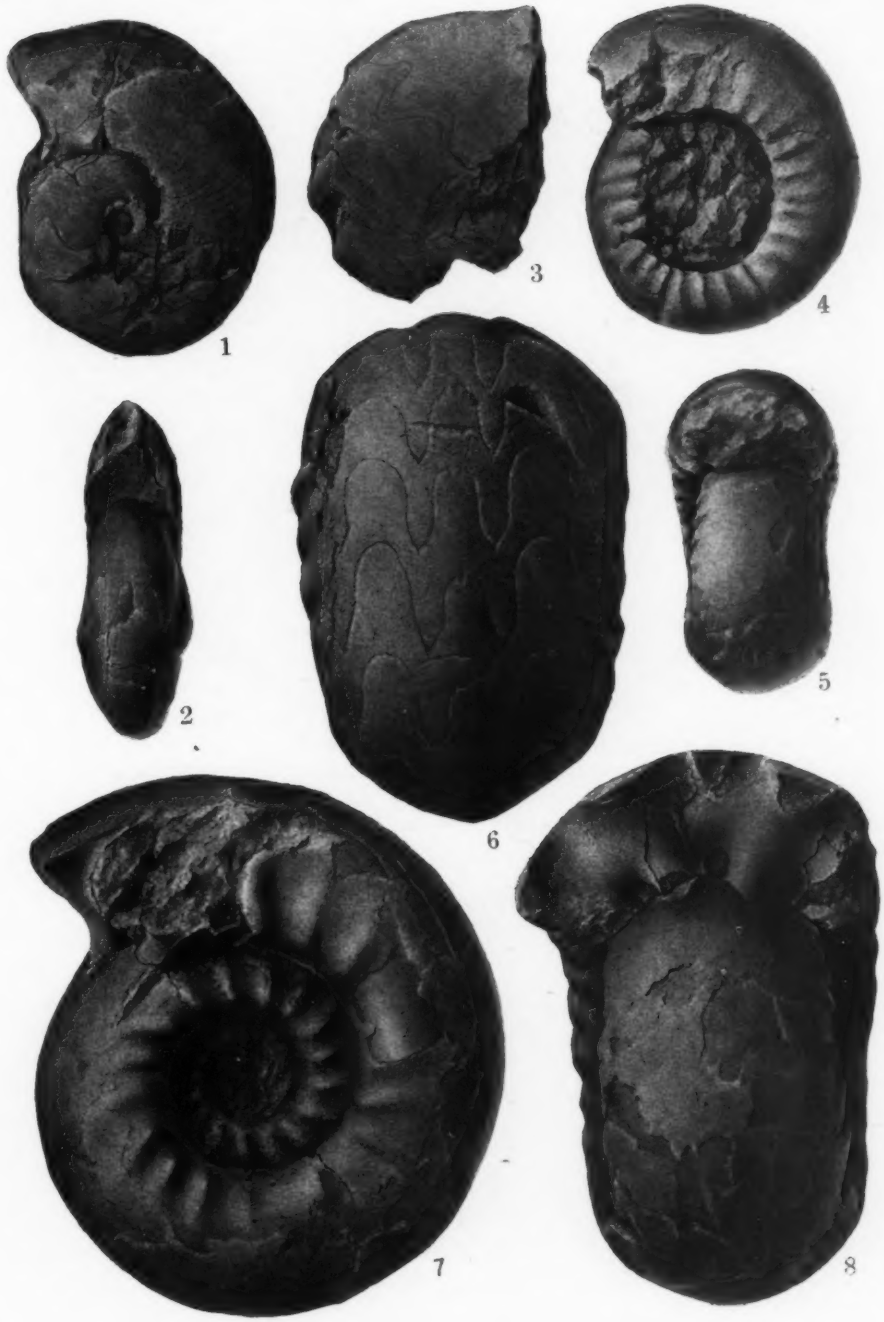
Glaphyrites oblatus MILLER and MOORE, 1938, Jour. Paleontology, vol. 12, pp. 352–353, pl. 43, figs. 10, 11.

This species is represented in the collections we are studying by 19 internal molds of phragmacones. The largest of them (pl. 66, figs. 12, 13) attains a maximum diameter of about 75 mm. Near the adoral end of this large specimen, the conch, which is helmet-shaped in cross section, is about 51 mm. wide and about 30 mm. high. During early growth stages the whorls are particularly broad (pl. 66, figs. 5, 6, 10, 11). The diameter of the umbilicus at full maturity is equal to about three-eighths that of the specimen. The umbilical shoulders are very abrupt, and the umbilical walls are steep, though distinctly convex exteriorly.

EXPLANATION OF PLATE 67

FIGS. *1–3*—*Goniolobоceras* sp. Two views (fig. *1*, *2*) of one specimen and one of another, from the "Pennsylvanian Caney" shale northwest of Frisco, Oklahoma, all ×1. (p. 428)

4–8—*Gastrioceras grileyi* Miller and Owen, n. sp. *4*, *5*, A paratype; *6*, *8*, the holotype. From the upper part of the Union Valley formation near Lovelady, about 7 miles southeast of Ada, Oklahoma, ×1. (p. 425)



Miller and Owen, Pennsylvanian Cephalopods

2

1

Miller and Owen, Pennsylvanian Cephalopods

None of the specimens under consideration retains a trace of the growth lines. However, on these internal molds there are rounded transverse constrictions, which are slightly sinuous, forming low ventral salients and similar ventrolateral sinuses. There are about four of these constrictions to the volution, and they are not very prominent. Presumably, they are essentially parallel to the growth lines.

The shape of the sutures during early and typical maturity is shown by text figures 3B and 4C. The latter illustration is based on a well-preserved portion of a fully mature whorl, on which the sutures can be followed throughout their entire length. Throughout ontogenetic development, the lobes tend to become more acuminate and the saddles more narrowly rounded.

Remarks.—Several of the representatives of this species in our Union Valley collections are of about the same size as the holotype, and they are strikingly similar to it. This form is a typical representative of the genus *Eoasianites*, of which *Glaphyrites* is a synonym. At the same time, it resembles *Cravenoceras? morrowense*, with which it occurs in association. Possibly that species should be referred to *Eoasianites*, but its conch is narrower than is that of the form under consideration and the transverse constrictions on it form ventral sinuses rather than salients—presumably this last feature is significant. Immature representatives of *Eoasianites oblatus* are very much broader than are those of *Cravenoceras? morrowense*.

Occurrence.—Abundant in impure arenaceous limestone at top of Union Valley formation along Buck Creek just north of Midland Valley Railroad near Lovelady in SE¼ NE¼ NE¼ sec. 29, T. 3 N., R. 7 E., about 7 miles southeast of Ada, Pontotoc County, Oklahoma. This species occurs also in the Morrow group of northwestern Arkansas and northeastern Oklahoma.

Repository.—John Britts Owen collection at the State University of Iowa, 13951 (figured specimens) and 13952.

Genus PSEUDOPARALEGOCERAS Miller, 1934

PSEUDOPARALEGOCERAS FRISCOENSE, n. sp.

Plate 66, figures 1, 2; text fig. 2A

From the Lower Pennsylvanian of southeastern Oklahoma we have six specimens that appear to represent an unnamed species of *Pseudoparalegoceras*. The largest and most nearly perfect of these (pl. 66, figs. 1, 2) is chosen as the holotype. It is about 36 mm. in diameter, and near its adoral end the conch is about 12 mm. high and about 13 mm. wide. The whorls are evenly rounded laterally and ventrally and are almost semicircular in cross section. The umbilical shoulders are subangular and the umbilical walls are rather steep. The diameter of the umbilicus is equal to almost half that of the specimen, and the maximum diameter of the umbilicus of the holotype measures about 17 mm.

The surface of the test bears fine, rather inconspicuous growth lines, which form broad, shallow rounded lateral salients and a similar ventral sinus. Also, in the internal mold (but apparently not the exterior of the test) there are rounded sinuous transverse constrictions approximately parallel to the growth lines. In general, there are about four of these constrictions to the volution.

As shown by text figure 2A, each mature suture forms a rather narrow divided ventral lobe, an asymmetrically U-shaped first lateral saddle, a broad V-shaped first lateral lobe, and a broad rounded saddle, which presumably extends to a lobe in the vicinity of the umbilical seam.

Remarks.—All of the paratypes are considerably smaller than the holotype, but otherwise they do not differ greatly from it. This species differs markedly from *Eoasianites oblatus*, the only similar form known from the Union Valley—its conch is much narrower and its umbilicus is larger. It seems to resemble *Pseudoparalegoceras lenticulare* (Plummer and Scott) of the Smith-

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EXPLANATION OF PLATE 68

FIGS. *1, 2*—*Gastrioceras fittsi* Miller and Owen, n. sp., Ventral and lateral views of the holotype, from the upper part of the Union Valley formation near Lovelady, about 7 miles southeast of Ada, Oklahoma, ×⅔. (p. 424)

wick (Bend) and Magdalena formations of Texas and *P. kesslerense* (Mather) of the Bloyd shale (Morrow) of Arkansas, but the similarity is not great.

Occurrence.—Fairly abundant in limonite concretions in the "Pennsylvanian Caney" shale along a small creek in sec. 8, T. 2 N., R. 7 E., northwest of Frisco, Pontotoc County, Oklahoma.

Types.—John Britts Owen Collection at State University of Iowa, 13965 (holotype) and 13966 (paratypes).

Genus GONIOLOBOCERAS Hyatt, 1900

GONIOLOBOCERAS sp.

Plate 67, figures 1–3

In association with the type specimens of *Pseudoparalegoceras friscoense* were found three specimens that appear to be referable to *Gonioloboceras*. All of these are somewhat crushed and are so poorly preserved that even their generic affinities can not be determined with certainty. The largest (pl. 67, fig. 1) is about 50 mm. in diameter. The preserved part of the specimen represented by figure 3 on plate 67 is about 44 mm. in diameter. The third specimen is of the same general magnitude but it represents less than half of a volution. The whorls are strongly flattened laterally, narrowly rounded ventrally, and deeply impressed dorsally. The venter is rounded and is not grooved as in some other representatives of this genus. The umbilicus is small and not very prominent. Its diameter measures only about one-tenth that of the conch.

The growth lines are fairly prominent on the exterior of the test. They are nearly straight and directly transverse on the flattened lateral zones, but on the ventrolateral zones they curve ventrad so as to form rounded ventral saddles.

The shape of the sutures can not be ascertained with certainty. However, each suture seems to form a broad divided ventral lobe, a narrowly rounded V-shaped first lateral saddle, an asymmetrical V-shaped first lateral lobe, and a broad second lateral lobe, which extends across the umbilical shoulder, presumably to a lobe on the umbilical wall.

Remarks.—None of the three specimens under consideration is well enough preserved to permit specific comparisons. This form is the oldest known representative of the genus *Goniolaboceras*.

Occurrence.—Limonite concretions in the "Pennsylvanian Caney" shale along a small stream in sec. 8, T. 2 N., R. 7E., northwest of Frisco, Pontotoc County, Oklahoma.

Repository.—John Britts Owen collection at State University of Iowa, 13967 (figured specimens) and 13968.

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JOURNAL OF PALEONTOLOGY, VOL. 18, NO. 5, PP. 429–447, PLS. 69–75, SEPTEMBER 1944

CRETACEOUS, TERTIARY, AND RECENT CORALS, A SPONGE, AND AN ALGA FROM VENEZUELA

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ABSTRACT—The reef limestones of the Barranquin, El Cantil, and Chimana formations (upper Aptian-lower Albian) in northeastern Venezuela contain a reef coral fauna expressive of the widespread Tethyan "Urgonian" facies, a fauna most closely allied to previously known coral faunas of southern Mexico and central Texas, and less so to the Urgonian coral fauna of southern France. Twenty-three species representing 19 genera of scleractinians and stromatoporoids are listed. Twenty of these species are described and figured, 13 being new, the rest having been previously described from the other areas mentioned. In addition, a new species of calcisponge, referred tentatively to *Corynella*, and a new but unnamed species of the calcareous alga *Halimeda*, both from the Barranquin formation, are described. Two ahermatypic corals are described from the Tertiary: *Caryophyllia clavus* from the Oligocene Carapita formation and a new species of *Dendrophyllia* from the Oligocene or Miocene. A list is given of 12 species of recent corals dredged from the harbor of Puerto La Cruz, pertaining to the modern Caribbean reef fauna.

CONTENTS

	Page
Introduction	429
Lower Cretaceous corals	429
Previous work	429
New material	430
Occurrence and relations of the coral fauna	430
Preservation	431
Systematic descriptions	432
A new sponge and an alga from the Barranquin formation	443
Tertiary corals	445
Recent corals from Puerto La Cruz	446
References	446

INTRODUCTION

THE MATERIAL from Venezuela described in this paper was collected by Dr. Hollis Hedberg of Barcelona, Venezuela, and by him turned over to the writer for study and description.[1] It consists of three different lots of fossil and Recent corals: one, the largest, from the Lower Cretaceous, a second, comprising a few Tertiary corals, and a third, of recent reef corals dredged from the harbor at Puerto La Cruz. The treatment accorded this assemblage is uneven—the Lower Cretaceous corals, which constitute a distinct fauna, are discussed and described at some length; the two Tertiary species are merely described; and the Recent corals are summarily listed with a few annotations.

[1] Preliminary results from a study of the Lower Cretaceous corals have previously appeared in a recent paper by Hedberg and Pyre (1944, p. 7).

The writer here expresses his appreciation to Dr. Hedberg for the opportunity of examining this important collection, and to the Mene Grande Oil Company for paying the cost of publishing the plates. The specimens are all deposited in the United States National Museum coral collections (U.S.N.M.).

LOWER CRETACEOUS CORALS

Previous work.—The only record and description of corals from the Lower Cretaceous of Venezuela is contained in a short paper by the late J. W. Gregory (1927), who studied small collections from two localities: Punceres, State of Monagas, and Port Piritú on the coast about 40 km. west of Barcelona, State of Anzoátegui. From Punceres, where the horizon is the El Cantil formation, he described.

Diplocoenia occidentalis Gregory (=*Diploastrea?*)
Thamnasteria harrisoni Gregory (=*Astrocoenia*)
And from Port Piritú
Thecosmilia sp. cf. *T. tobleri* Koby
Stylosmilia alpina Koby? (=*S. gregorii*, n. sp.)
Diplarea venezuelensis Gregory (=*Calamophyllia sandbergeri* Felix)
Metethmos sp.
Thamnaraea or *Dimorpharaea* sp.

The horizon at Port Piritú is not definitely known,[2] but the few corals listed above suggest that it is in the reef limestones of the upper Barranquin formation.

New material.—The new material to be described below consists of specimens from several localities and horizons, as follows:

1. Las Cinco Ceibas, about 10 km. south of Cumaná on the road to Cumancoa, State of Sucre, northeastern Venezuela. Horizon: Upper Barranquin formation, in limestones transitional to overlying formation:

Astrocoenia barranquinensis Wells, n. sp.
Cyathophora hayensis Wells
Cyathophora hedbergi Wells, n. sp.
Stylosmilia gregorii Wells, n. sp.
Stylina sucrensis Wells, n. sp.
Myriophyllia borrachensis Wells, n. sp.
Enallhelia occidentalis Wells, n. sp.
Stylangia laddi Wells, n. sp.
Calamophyllia sandbergeri Felix
Periseris irregularis (Felix)
Meandrophyllia cariacoensis Wells, n. sp.
Meandrophyllia plummeri Wells
Actinaraea arborescens (Felix)
Thecosmilia cumanensis Wells, n. sp.
Elasmophyllia tolmachoffana Wells
Cladophyllia stewartae Wells, n. sp.
Budaia felixi Wells, n. sp.
Stromatopora venezuelensis Wells, n. sp.

2. La Borracha Island, off Guanta coast, State of Anzoátegui. Horizon: upper Barranquin formation, reef limestones:

Stephanocoenia guadalupae Wells

3. La Borracha Island, off Guanta coast, State of Anzoátegui. Horizon: lower Chimana formation, limestones gradational with the upper part of the El Cantil formation:

Myriophyllia borrachensis Wells, n. sp.
Meandrophyllia plummeri Wells
Dendraraea anzoateguensis Wells, n. sp.

Occurrence and relations of the coral fauna.—In northeastern Venezuela corals occur in the reef limestone facies of the Barranquin, El Cantil, and Chimana formations of upper Aptian to lower Albian age.[3] In the Barranquin formation this facies lies in the upper part and is transitional into the overlying lower beds of the El Cantil. It appears again in the upper part of the El Cantil and passes laterally into the Chimana formation. Thus there are two reef-coral horizons in

[2] Concerning this locality, Dr. Hedberg says (personal communication):
"There are no Cretaceous rocks outcropping anywhere in the immediate vicinity of Puerto Piritú, and while there are some uppermost Cretaceous sediments exposed farther west in the range of hills extending from Puerto Piritú to the Rio Unare, no Middle or Lower Cretaceous rocks are known until the western side of the Rio Unare is reached. This is some 20–30 km. distant. I cannot help but think that there must be some mistake with regard to the locality of Gregory's corals or that they came from boulders in the Miocene conglomerate exposed near Piritú."

[3] For more complete data on these formations see Hedberg and Pyre (1944).

EXPLANATION OF PLATE 69

Numbers in parentheses refer to U. S. Nat. Mus. catalogue.

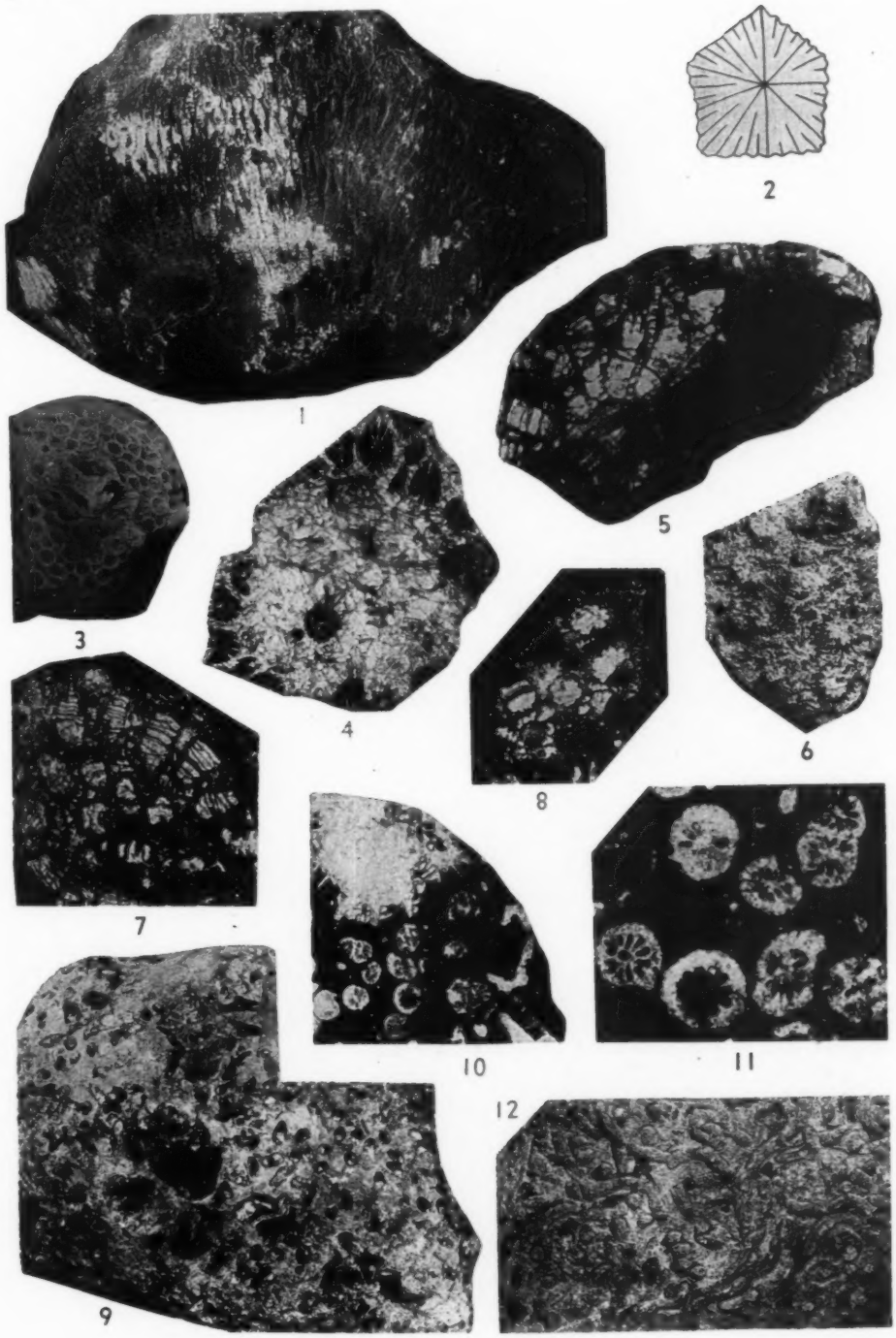
FIGS. *1, 2—Astrocoenia barranquinensis* Wells, n. sp. *1*, Holotype, lateral aspect, ×2½; *2*, diagram of transverse section of a corallite, ×5.4, (547380). (p. 432)

3, 4—Stephanocoenia guadalupae Wells. *3*, General view of corallum, ×0.9; *4*, transverse section, ×2½, (547381). (p. 433)

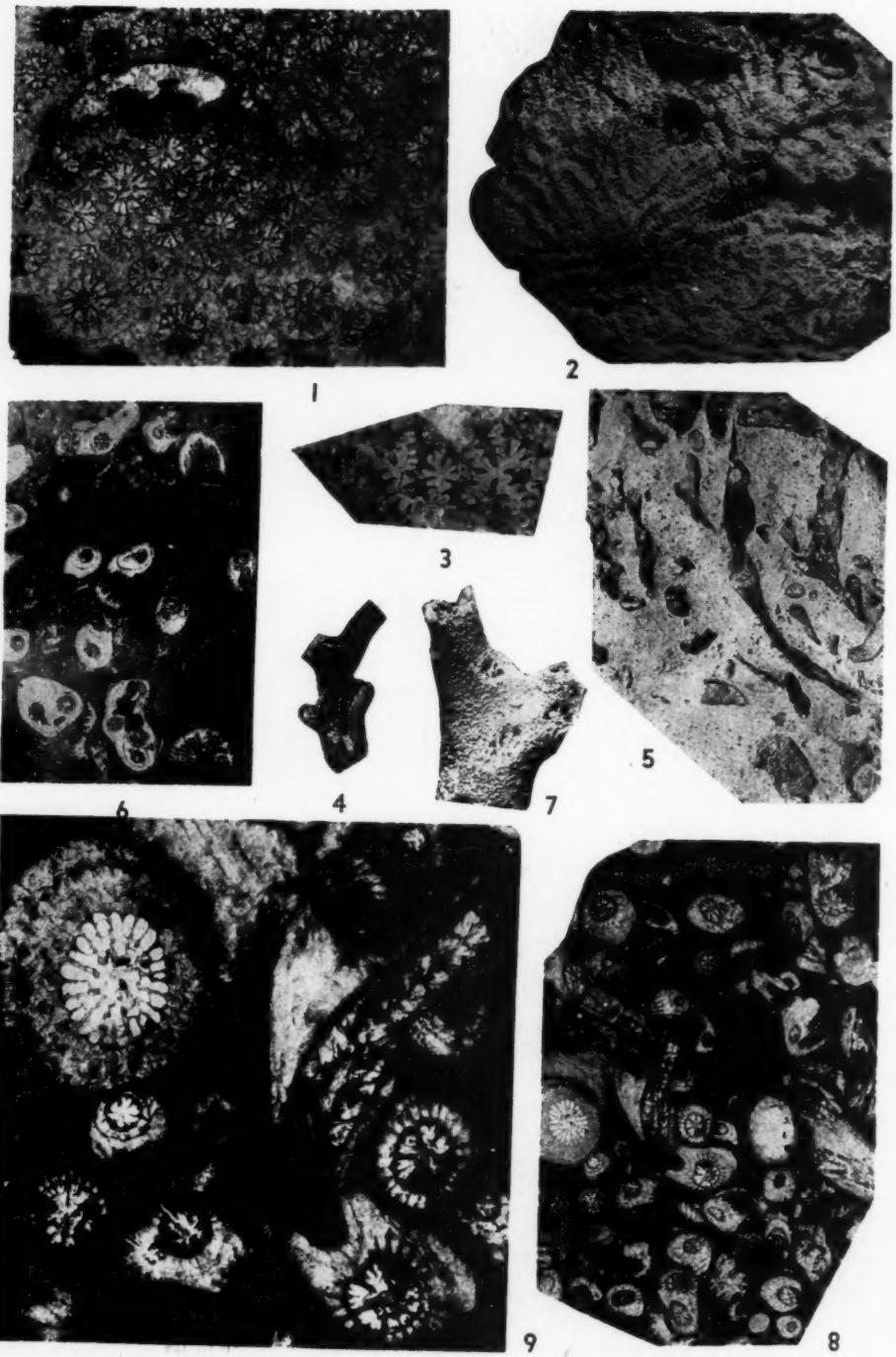
5, 6—Cyathophora haysensis Wells. *5*, Vertical section, ×2½; *6*, exterior of corallum, ×2½, (547382). Dark mass at right of *4* is *Stromatopora venezuelensis* Wells, n. sp. (p. 433)

7, 8—Cyathophora hedbergi Wells, n. sp. Vertical and transverse sections of holotype, ×2½, (547383). (p. 434)

9–12—Stylosmilia gregorii Wells, n. sp. *9*, *10*, Transverse sections of holotype, ×2½, ×5.4; *11*, exterior of holotype, ×0.9, (547384); *12*, paratype, ×0.9, (547383). (p. 434)



Wells, Venezuelan Corals



Wells, Venezuelan Corals

this sequence—a lower one in the upper Barranquin and an upper in the reef facies of the upper El Cantil and lower Chimana formations. The material studied contains specimens from both, but the collection from the upper horizon represents only three species and is obviously very incomplete. On the basis of the material at hand, however, there is little or no evidence that two distinct faunas are involved but it appears that we are here dealing with a repetition of the same reef-coral environment.

The corals of the Barranquin, El Cantil, and Chimana reef facies are wholly hermatypic or reef-building types. They represent an assemblage indicative of quiet waters—shallow lagoons behind reefs, as suggested by the many delicate branching and fasciculate growth forms and comparative absence of stout, massive agitated-water or reef-face forms. None of the specimens seems to occur in situ at the localities now known, and all show signs of rolling and breaking by water action and riddling by lithophagous mollusks.

The fauna is another example of the very widely distributed Tethyan "Urgonian" coral-caprinid facies of the Neocomian in Europe, East Africa, Japan, Texas, and Mexico. In the Tehuacan region of southern Mexico it occurs in the Barremian, Aptian, and lower Albian (Müllerried, 1934); in central Texas in the lower Albian (lower Glen Rose formation). The Texas and Mexican faunas are interrelated, that of Texas being the northern and somewhat younger expression of the Tehuacan fauna, and neither is closely related to the more or less contemporaneous Tethyan assemblages of the Old World. The Venezuelan Urgonian fauna however, is significant in that it shows relations, not only to the Tehuacan and Texas faunas, as would be anticipated, but also to those of the western part of the Tethys, especially the Urgonian corals of eastern France. Several genera, such as *Enallhelia*, *Stylosmilia*, *Dendraraea*, and *Stromatopora*, which do not occur in Tehuacan and Texas, are represented in Venezuela. Several of the new Venezuelan species, further, are not related to American congeners but find their nearest allies among European forms. The connections of the Venezuelan Urgonian coral fauna, including those reported by Gregory from Punceres and Port Piritú, but not found in the present collections, are focussed in the distribution table.

In the same stratigraphic province as the Barranquin, El Cantil, and Chimana formations are the still poorly known Lower Cretaceous beds of the Central Range of Trinidad (Cuche River beds of Kugler; *see* Vaughan and Cole, 1941, table 1), from which J. W. Gregory described the first coral in 1929, *Dendroseris harrisoni*, from a locality on the Cush river at Bousignac. It is not a new fungiid genus but a ramose *Stylina*. The writer is describing in another paper a small collection of corals made by Gunther, Renz, and Rutsch from the same beds of the Central Range. This collection includes not only *S. harrisoni* but also *Calamophyllia sandbergeri* and other species that occur in the Barranquin formation of Venezuela and in southern Mexico, and new species of *Myriophyllia* and *Baryphyllia*.

Preservation.—The condition of preservation of the Venezuelan Urgonian corals leaves much to be desired. Most of the species are in the form of fragments of corallites embedded in worn blocks of limestone, in such shape that very few show external structures. Therefore they have been studied mostly from sections, and even here in many cases the internal structure has been partially obliterated by replacement and recrystallization. Adequate illustration of the corals has been a serious problem, but so far

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EXPLANATION OF PLATE 70

FIGS. *1*—*Stylina sucrensis* Wells, n. sp. Transverse section of holotype, ×5.4, (547385). (p. 435)
2, *3*—*Myriophyllia borrachensis* Wells, n. sp. *2*, Surface of holotype, ×0.9; *3*, polished section, ×2½, (547386). (p. 436)
4–6—*Enallhelia occidentalis* Wells, n. sp. *4*, *5*, Fragments of branches of holotype, ×2½, ×0.9; *6*, transverse section of holotype, ×2½, (547387). Note *Calamophyllia sandbergeri* Felix in lower right of *6*. (p. 437)
7–9—*Stylangia laddi* Wells, n. sp. *7*, Exterior of paratype fragment of branch, ×2½, (547390); *8*, *9*, transverse section of holotype, ×2½, ×5.4, (547388). (p. 437)

DISTRIBUTION OF VENEZUELAN URGONIAN CORALS

Species	NE. Venezuela		Tehuacan region, Mexico	L. Glen Rose formation, Texas	European Urgonian
	U. Barranquin form.	U. El Cantil-L.Chimana form.			
Stylina sucrensis	x		*S. tehuacanensis*		*S. pachystylina*
Stylangia laddi	x		*S. anomalos*		
Calamophyllia sandbergeri[4]	x		x		*C. compressa*
Actinaraea arborescens	x		x		
Astrocoenia harrisoni		x		*A. whitneyi*	
Stephanocoenia guadalupae	x			x	
Cyathophora haysensis	x			x	
Meandrophyllia plummeri	x	x		x	
Elasmophyllia tolmachoffana[4]	x			x	
Astrocoenia barranquinensis	x				*A. excavata*
Cyathophora hedbergi	x				*C. regularis*
Stylosmilia gregorii	x				*S. alpina; S. gracilis*
Myriophyllia borrachensis	x	x			
Enallhelia occidentalis	x				*E. rathieri; E. gemmans*
Meandrophyllia cariacoensis	x				*M. meandroides*
Diploastrea? occidentialis		x			
Dendraraea anzoateguensis		x			*D. cancellata*
Thecosmilia cf. T. tobleri	(Pt. Piritú)				*T. tobleri*
Thecosmilia cumanensis	x				
Cladophyllia stewartae	x				
Budaia felixi	x				
Stromatopora venezuelensis	x				(*S. minutissima*, U. Jura., Japan)

[4] Also recognized by the writer in undescribed material from Trinidad, B.W.I.

as possible each form is represented by photographs that show at least the essential characteristics by which they can again be recognized.

SYSTEMATIC DESCRIPTIONS

Phylum COELENTERATA
Class ANTHOZOA
Subclass HEXACORALLIA
Order SCLERACTINIA
Suborder ASTROCOENIIDA
Family ASTROCOENIIDAE
Subfamily ASTROCOENIINAE
Genus ASTROCOENIA Milne-Edwards and Haime, 1848

ASTROCOENIA BARRANQUINENSIS Wells, n. sp.

Plate 69, figures 1, 2

Corallum massive, forming relatively large hemispherical heads up to 2 decimeters in extent. Corallites prismatic, three- to six-sided, with thin, fused walls that may appear zigzag in sections. Diameter, 3 to 3.5 mm. Calices not preserved. Septa thin like the walls, about 36 in number, approximately equal in thickness, usually arranged in three cycles, commonly 9, 9, and 18. Those of the first series extend to the columella; those of the second a little more than halfway; and those of the third about one-third; all but those of the first cycle free on their inner ends. Columella a very small, weak, axial style. Dissepiments thin, subtabular.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. One specimen, the holotype (U.S.N.M. no. 547380).

Remarks.—There is no other species of *Astrocoenia* known from the Cretaceous of the Americas in which the corallites are so

large or the septa so numerous as in this species. The only comparable form is *A. excavata* de Fromentel (1884, p. 533, pl. 143, fig. 2; Koby, 1897, p. 60, pl. 12, figs. 1–4) from the Valanginian of Switzerland and Hauterivian of France, which has very slightly larger corallites and very similar structures—thin walls, thin septa, weak columella. Although the septa are said to be octamerally arranged in *A. excavata*, a kinship between the two is suggested.

Thamnastrea harrisoni Gregory (1927, p. 442, pl. 13, figs. 2a–c) from the El Cantil formation at Punceres, State of Monagas, is, as pointed out by Gerth (1928, p. 14) an *Astrocoenia*. The corallites are smaller than those of *A. barranquinensis* and the septa regularly hexameral. It is very closely allied to *A. whitneyi* Wells (1932, p. 230, pl. 31, fig. 6; pl. 32, figs. 1, 2; pl. 37, fig. 1) from the Glen Rose formation of Texas.

Genus STEPHANOCOENIA Milne-Edwards and Haime, 1848

STEPHANOCOENIA GUADALUPAE Wells 1932

Plate 69, figures 3, 4

Stephanocoenia? guadalupae WELLS, 1932. Jour. Paleontology, vol. 6, p. 235, pl. 32, figs. 8, 9; pl. 39, fig. 3.

Corallum nodular, subspherical, with a few prominences formed by protuberant corallite clumps. Diameter about 4 cm. Corallites cylindrical, closely appressed, occasionally subpolygonal, with slightly projecting shallow, circular calices, 2.0 to 2.5 mm. in diameter, with thick walls. Septa 24 in number, hexamerally arranged in three complete cycles, laterally strongly spinose, those of the first two cycles subequal and extending to the columella, whereas the 12 septa of the third cycle are thinner and extend less than half the distance between wall and columella. Columella a short, irregular, apparently twisted lamellar strip, appearing in the bottom of the calices as a short, thick bar united to the inner margins of the larger septa by trabecular processes. In some calices the confusion between these processes and the columella makes the latter appear parietal. The inner ends of the 12 larger septa, especially when seen in thin section, are swollen, and some of them have separate pali that appear to form a ring of 12 around the columella. None of the calices is sufficiently well preserved to show this well, but one or two do show a dozen knobs on the inner ends of the septa around the columella.

Occurrence and material.—Barranquin formation, La Borracha Island off Guanta coast, State of Anzoátegui, northeastern Venezuela. One specimen (U.S.N.M. no. 547,381). Lower Glen Rose formation (lower Albian), central Texas (Wells, 1932).

Remarks.—Because of poor preservation of the interior of the corallum and its worn exterior surface, certain details concerning dissepiments, costae, and septal margins are lacking. But the reference to this species seems justified on the basis of the columellar and palar structure, the aspect of the calices, and the number and arrangement of the septa. The only discernible difference is that the calices of the specimens from Texas are not so closely appressed, with costal interspaces 0.5–1.5 mm. wide, but this is no greater than the variation found in the living *S. michelini* of the Caribbean.

Columnastraea antiqua Gerth (1928, p. 5, pl. 1, figs. 4, 4a) from the Aptian of Neuquen, Argentina, according to Gerth has 12 pali of paliform lobes before the 12 larger septa and therefore is a *Stephanocoenia*. It differs from the present species by its smaller (1–2 mm.) calices and ramose growth form. The writer has described in manuscript a variety of *S. guadalupae*, from the upper Aptian or lower Albian of the state of Sonora, Mexico, in which the corallites are closely spaced and have a maximum diameter of 1.5 mm.

Family STYLINIDAE

Subfamily CYATHOPHORINAE

Genus CYATHOPHORA Michelin, 1843

CYATHOPHORA HAYSENSIS Wells, 1932

Plate 69, figures 5, 6

Cyathophora haysensis WELLS, 1932. Jour. Paleontology, vol. 6, p. 237, pl. 30, fig. 4; pl. 32, fig. 5.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. One specimen (U.S.N.M. no. 547382). Lower Glen Rose formation (lower Albian), Hays County, Texas.

Remarks.—The single specimen identified

with this species is part of a small hemispherical colony originally about 3 cm. in diameter and 1.5 cm. high. It seems to have grown on the irregular surface of a coenosteum of *Stromatopora venezuelensis*. Its structures check closely with the Texan material: calices, 2.5 to 3 mm., tabulae four in 2 mm., centers 3 to 4 mm. apart, septa 20 to 24. In the original description of *C. haysensis* the number of septa was incorrectly given as 10–12. This figure refers to the number of well-developed septa of the first two cycles. Actually, as shown in one of the figures (Wells, 1932, pl. 30, fig. 4), there is an equal number of rudimentary septa. This correction places the form very close to *C. atempa* Felix (1891, p. 155, pl. 25, fig. 8) from the upper Aptian of the Tehuacan region, southern Mexico. This species, however, has consistently smaller (2–2.5 mm.) corallites which are very closely appressed with somewhat fewer (18–22) septa.

CYATHOPHORA HEDBERGI Wells, n. sp.
Plate 69, figures 7, 8

Corallum small, nodular or subhemispherical. Corallites averaging 2 mm. in diameter, cylindrical, separated by less than 0.5 to 1.0 mm., in places fused together, with very low costae. Septa 12 in number, those only of the first cycle well developed and extending less than halfway to the corallite axis, the remainder being very rudimentary, scarcely apparent in the holotype. Tabulae complete, slightly arched upwards, irregularly spaced about four per mm.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. Four specimens (holotype, U.S.N.M. no. 547383; paratypes nos. 547393, 547394, and 547400).

Remarks.—Although this species is based on imperfect material, it is so different from the other American forms, *C. atempa* and *C. haysensis*, that it should easily be recognized, especially on the basis of the weaker development of the septa, which are only half as numerous as in most corallites of the species mentioned. There are several European Lower Cretaceous species in which only two septal cycles are present: *C. icaunensis* (d'Orbigny) (de Fromentel, 1884, p. 539, pl. 147, fig. 3) from the Hauterivian of France, which has much larger (3–3.5 mm.) corallites; *C. pygmaea* Volz (1903, p. 26, pl. 4, figs. 4–7) from the Neocomian of Bukowina, which has much smaller) 0.5–0.7 mm.) corallites; and *C. regularis* de Fromentel (1884, p. 540, pl. 149, fig. 2; Koby, 1897, p. 29, fig. 5) from the Hauterivian of France and Switzerland, which has slightly larger corallites (2.5 mm.) and which may be closely related to *C. hedbergi*.

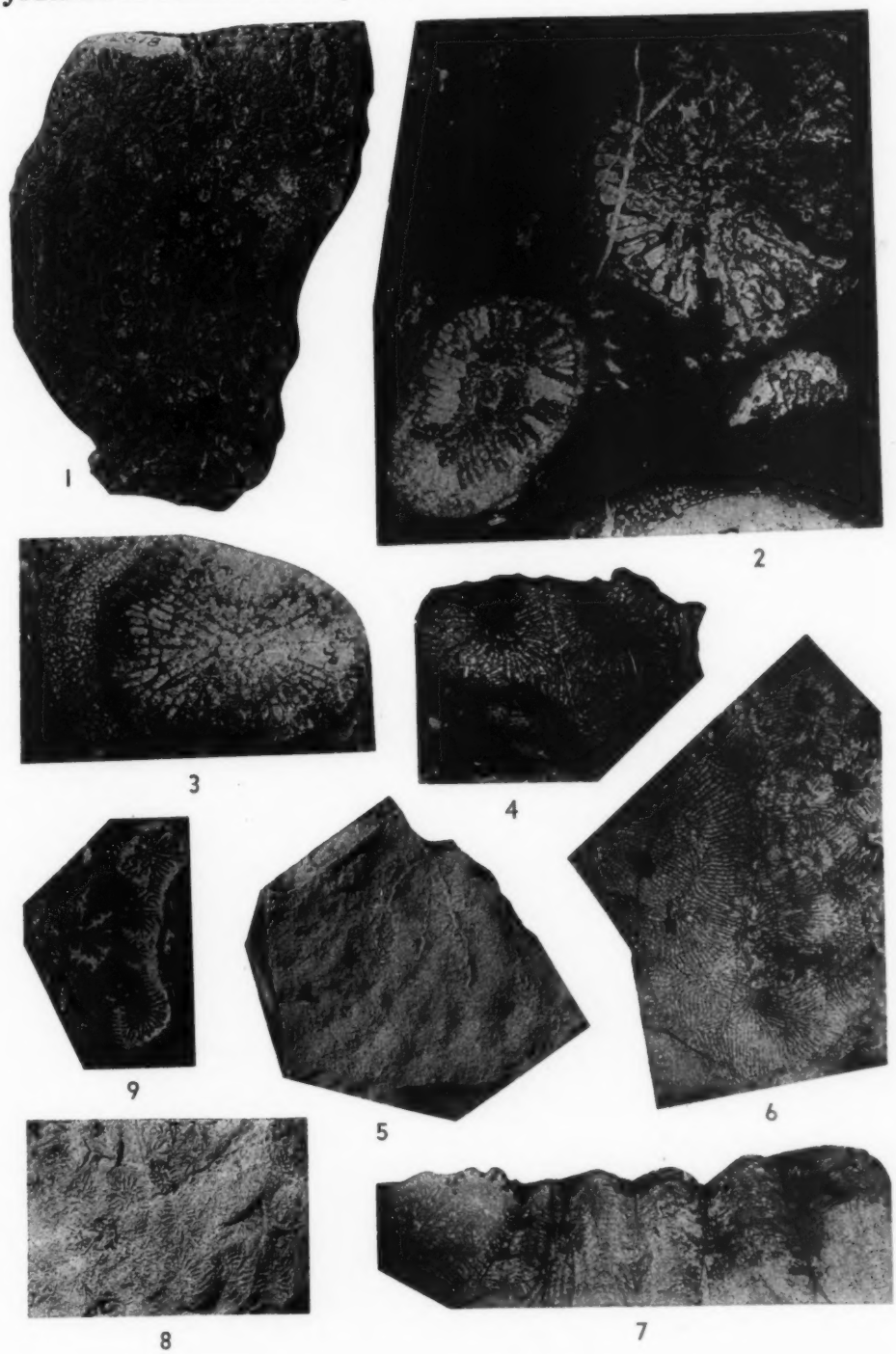
Subfamily STYLININAE
Genus STYLOSMILIA Milne-Edwards and Haime, 1848
STYLOSMILIA GREGORII Wells, n. sp.
Plate 69, figures 9–12;
plate 72, figure 4

Stylosmilia alpina? GREGORY, 1927, Geol. Mag., vol. 64, p. 440. Not KOBY, 1897, Soc. paléont. Suisse Mém., vol. 23, p. 36, pl. 7, figs. 6, 7.

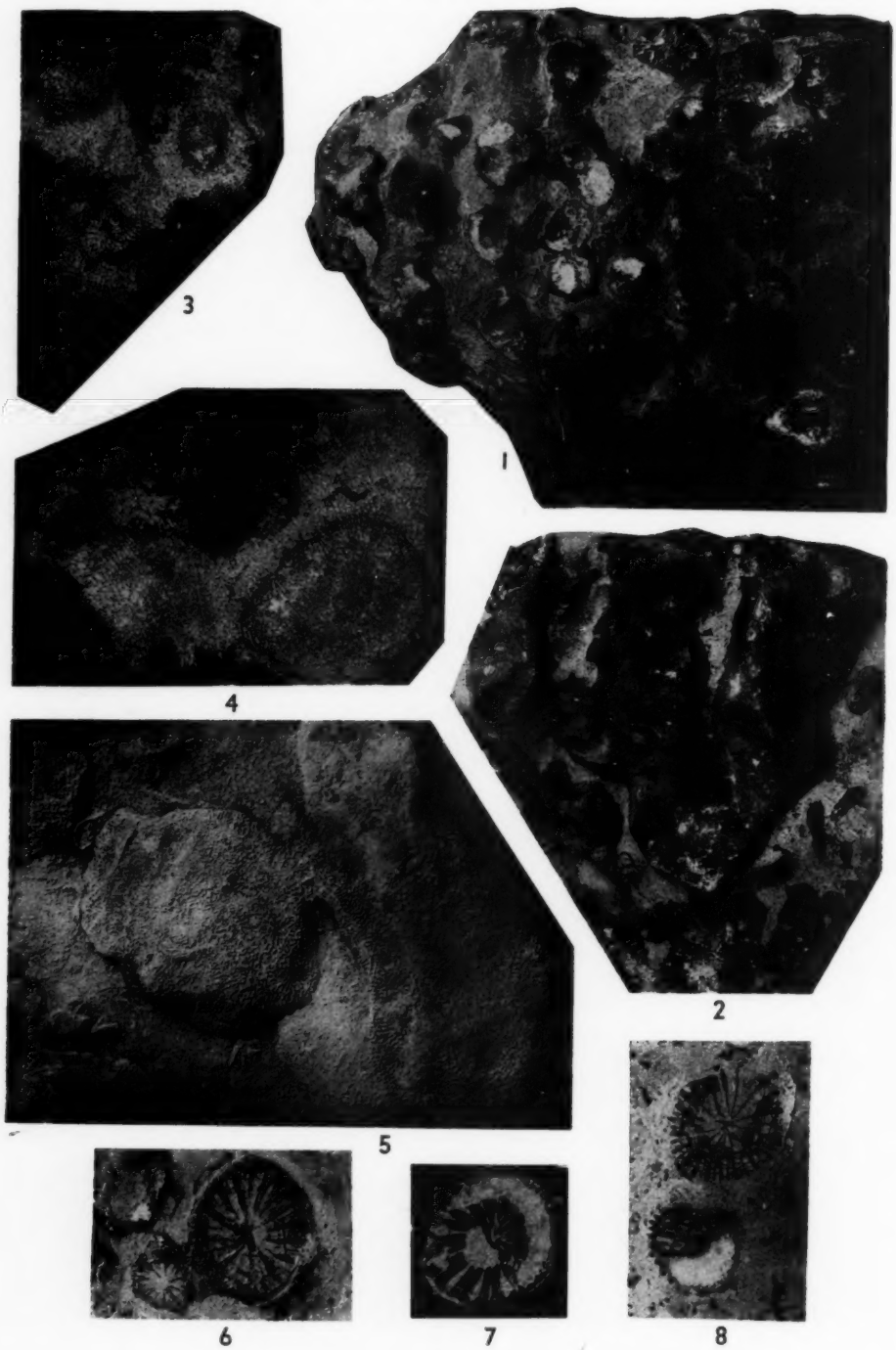
Corallum phaceloid, forming small clumps. Colony formed by alternate extratentacular budding near tips of corallites at about 45 from the axis. Exterior of corallites not observed. Corallites cylindrical, from 1.5 to 2.0 mm. in diameter, commonly nearer 1.5, with thick, costate walls. Septa 12 in number, in two complete cycles of six each, nearly equal, thick, crenulated along inner margins, all seeming to extend to the columella, where they are thickened, but probably, as a rule,

EXPLANATION OF PLATE 71

FIGS. *1*—*Stylangia laddi* Wells, n. sp. Exterior of holotype, ×0.9, (547388). (p. 437)
2, 3—*Calamophyllia sandbergeri* Felix. *2*, Transverse section, ×5.4, (547399). *Thecosmilia cumanensis* at upper right, *Stromatopora venezuelensis?* at bottom; *3*, transverse section, with adherent *S. venezuelensis?*, (547390). (p. 438)
4—*Periseris irregularis* (Felix). Transverse section, ×2¼, (537383). (p. 439)
5–7—*Meandrophyllia plummeri* Wells. *5*, Calicular surface, ×0.9; *6, 7*, transverse and vertical sections, ×2¼, (547391). (p. 439)
8, 9—*Meandrophyllia cariacoensis* Wells, n. sp. *8*, Worn calicular surface of paratype, ×2¼, (547394); *9*, transverse section of holotype, ×2¼, (547393). (p. 440)



Wells, Venezuelan Corals



Wells, Venezuelan Corals

only the first-cycle septa actually join it. Columella stout, styliform.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. Three specimens: holotype (U.S.N.M. no. 547384) and two paratypes (U.S.N.M. nos. 547383, 547395). "Urgonian" (probably upper Barranquin formation), at Port Piritú, west of Barcelona, State of Anzoátegui, northeastern Veneuzela (Gregory, 1927).

Remarks.—Gregory's specimens were not further described beyond an indication that the diameter of the corallites was 1.5 mm., but they are almost certainly conspecific with the material from Las Cinco Ceibas. The species is closely allied with *S. alpina* Koby from the Swiss Neocomian, the essential difference being in the consistently larger (2–2.5 mm.) corallites of that species. *S. neocomiensis* de Fromentel (1873, p. 420, pl. 76, fig. 1) from the French Neocomian has larger corallites with a third cycle of 12 septa. *S. gracilis* de Fromentel (1873, p. 421, pl. 76, fig. 2) from the Valanginian at Gy-l'Évêque (Yonne), is a related species with 12 nearly equal septa and corallites averaging 1.5 mm. *S. brevis* d'Orbigny (de Fromentel, 1873, p. 422, pl. 84, fig. 2), from the Hauterivian at Leugny (Yonne), which has never been properly described, although figured by de Fromentel, who suggested that it is the same species as *S. gracilis*, is said by Corroy (1925, p. 304) to have larger corallites, with deep calices and more septa.

Genus STYLINA Lamarck, 1816
STYLINA SUCRENSIS Wells, n. sp.
Plate 70, figure 1

Corallum forming irregularly nodular masses of moderate size. Corallites small, cylindrical, with costate walls commonly so thickened by stereome that no interspaces are evident, appearing in thin section as a solid perithecal mass in which the costae are faintly visible. Internal diameter averaging 1.5 mm. Centers about 1.5 mm. apart. Septa octamerally arranged in two cycles of 8 each. Those of the first cycle seem to form two tetrameral groups, one of which may be slightly thicker than the other and extending to the columella, with the septa of both groups considerably expanded inward. This appearance of two groups of first cycle septa, however, is only apparent, being produced in section by the alternation of the inner marginal septal denticulations by which the septa are united to the columella. Septa of the second cycle of eight thinner and extending less than halfway to the columella. Columella styliform, weakly developed in many corallites.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. One specimen (holotype: U.S.N.M. no. 547385).

Remarks.—Species of the protean, characteristically Jurassic genus *Stylina* are very rare in the American Cretaceous. Two other records are known: *S. harrisoni* from the Middle (?) Cretaceous of Trinidad, and *S. tehuacanensis* from the Aptian of southern Mexico. *S. harrisoni*, originally described as the type of a new fungiid genus, *Dendroseris*, by Gregory (1929, p. 66, pl. 8), is clearly a *Stylina* differing from *S. sucrensis* by its ramose growth form and hexamerally arranged (6/6) septa. *S. tehuacanensis* (Felix) (1891, p. 161, pl. 22, figs. 2, 8, 8a), originally placed by Felix in *Stylophora*, and based upon imperfect material, is a *Stylina* with an uncertain septal organization. Felix refers only to six well-developed septa and a columella, but his figures show eight major septa in each calyx. *S. tehuacanensis* and *S. sucrensis* may prove to be of the same species.

The new species belongs to the species group of *Stylina* characterized by octamer-

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EXPLANATION OF PLATE 72

FIGS. *1–5*—*Actinaraea arborescens* (Felix). *1*, *2*, Top and lateral views of large corallum, ×0.45; *3*, *4*, thin sections across branches, ×2; *5*, calicular surface of branches, ×2½, (547395). Note solitary corallite of *Stylosmilia gregorii* in upper part of *4*. (p. 440)

6–8—*Elasmophyllia tolmachoffana* Wells. *6*, Worn corallite with immature bud, ×2, (547387); *7*, transverse section of corallite, ×2½, (547393). Note septothecal wall and epitheca over edges of costae. *8*, Polished section, ×2½, (547394) (p. 442)

ally or tetramerally arranged septa with four of these appearing more prominently than the rest, and is allied to several European Neocomian species: *S. elegans* Eichwald (*see* Solomko, 1887, p. 27, pl. 1, fig. 4—as *Stylocoenia geminata*) from the Crimea, which has very closely appressed or fused corallites; *S. pachystylina* Koby (1896, p. 26, pl. 5, figs. 6, 6a) from the Urgonian of Morteau (Doubs), which has slightly larger, more widely spaced corallites with an unusually stout columella; *S. parvistella* Volz (1903, p. 19, pl. 3, figs. 13–20) from Bukowina, which has much smaller corallites; and *S. elegans* d'Orbigny (see Volz, 1903, p. 17), also recorded from Bukowina, in which a third group of 16 septa is fully developed.

Genus MYRIOPHYLLIA d'Orbigny, 1849

MYRIOPHYLLIA BORRACHENSIS Wells, n. sp.

Plate 70, figures 2, 3

Corallum forming small laminar masses. Colony formation by intratentacular intramural, with some circumoral, budding, producing meandrine series. Series with closely fused walls, lacking ambulacra, over the tops of which the septa may or may not be confluent. Series averaging 2.5 mm. in width. Septa thick, weakly alternating in size, parallel, relatively distant, from 7 to 9 in a distance of 5 mm., free on their inner ends where columella is absent, or alternate ones fused to columella where it is developed; 12 around corallite centers of monostomatous polyps. Endothecal dissepiments thin, tabular, about 6 in a distance of 5 mm. Columella lamellar, discontinuous, deep in the corallite series, commonly very weak or even absent.

Occurrence and material.—Chimana formation, La Borracha Island, off Guanta coast, State of Anzoátegui, northeastern Venezuela; one specimen (holotype: U.S.N.M. no. 547386). Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela; one specimen (U.S.N.M. no. 547402).

Remarks.—Species of *Myriophyllia* (*Eugyra*) are rather difficult to discriminate, particularly when represented by imperfect material, and further because of the individual variation in development of structures, especially the columella, which has apparently been overlooked by many investigators. There are several other American Lower Cretaceous species of the genus: *M. cotteaui* d'Orbigny (Felix, 1891, p. 159), *M. neocomiensis* de Fromentel (Felix, 1891, p. 159), and *M. mariscali* (Felix) (1891, p. 261, pl. 24, figs. 4, 4a), from the Barremian and Aptian of the Tehuacan region, southern Mexico; *M. cuyleri* Wells (1932, p. 237, pl. 34, fig. 4) from the lower Glen Rose formation of Texas; and *M. dumblei* Wells (1933, p. 149, pl. 5, fig. 10) from the Edwards limestone of Texas. The identity of the Mexican specimens with the European species indicated by Felix is not established, and it is probable that they are distinct. Felix does not mention a columella in either his *M. cotteaui* or *M. neocomiensis*. The writer studied d'Orbigny's types of *M. cotteaui* (Paris Museum, coll. d'Orbigny, nos. 5308, 5308A) from the Hauterivian at St. Saveur and Fontenoy, France, and definitely ascertained the existence of a lamellar columella. Topotypes of *M. neocomiensis* de Fromentel (1877, p. 442, pl. 103, fig. 1) from the Valanginian at Gy-l'Évêque (Yonne) in the Paris Museum, however, have no trace of a columella. The taxonomy of the Mexican *Myriophylliae* awaits further study of actual material; for the present they are placed in affinity with the European forms to which they are probably allied. The following analysis shows the salient characters of the American forms:

AMERICAN SPECIES OF MYRIOPHYLLIA

I. Columella present.
  A. Columella weakly developed; series 2.5 mm. wide; septa slightly alternating, 7–9 in 5 mm. . . . . *M. borrachensis* Wells, n.sp.
  B. Columella well developed.
    1. Series 1.5–2 mm. wide; septa equal; 10–12 in 5 mm. . . . . *M. dumblei* Wells
    2. Series 2–4 mm. wide; septa alternating, 14–16 in 5 mm. . . . *M. mariscali* (Felix)

II. Columella absent.
  A. Series 1–1.5 mm. wide; septa weakly alternating, 15–20 in 5 mm. . . . . *M.*, n.sp. (Trinidad)
  B. Series 1–2 mm. wide, septa alternating, 17–25 in 5 mm. . . . . *M.* sp. aff. *M. neocomiensis* (de Fromentel) (Felix)
  C. Series 2 mm. wide; septa equal, 7–10 in 5 mm. . . . . *M. cuyleri* Wells
  D. Series 2–4 mm. wide; septa alternating, 10–14 in 5 mm. . . . . *M.* sp.aff. *M. cotteaui* (d'Orbigny) (Felix)

The holotype of *M. borrachensis* is a fragment of a moderate-sized colony with nearly even upper surface on which the series are fairly long and rarely monocentric. The specimen from Las Cinco Ceibas is in a weathered block showing a fragment of a small corallum with very short series and several monocentric corallites with 10–15 septa around each center.

Genus ENALLHELIA Milne-Edwards and Haime, 1849

ENALLHELIA OCCIDENTALIS Wells, n. sp.

Plate 70, figures 4–6

Corallum dendroid; branches formed by alternate extratentacular budding at about 45°, slender, 2–4 mm. in thickness, corallites commonly lying in one plane. Corallites cylindrical, to 1–1.5 mm. in internal diameter, from 2 to 3 mm. apart on same side of branch, walls somewhat thickened by peritheca. Greatest thickness of peritheca rarely more than diameter of a corallite. Surface of peritheca apparently smooth or minutely granulated. Septa 12 in number, hexamerally arranged in two complete cycles. Septa of first cycle thin, inner margins swollen by spinose denticulations about 0.5 mm. apart where they are attached to the columella. Two opposing septa lying in the plane of the branch commonly slightly thicker and probably more exsert. Septa of second cycle short, thin, extending at least halfway to columella. Columella styliform, small but well developed.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. One specimen (holotype, U.S.N.M. no. 547387).

Remarks.—The holotype consists of several scraps of branches imbedded in a small block of limestone, hence the general form of the corallum and details of the exterior are not shown. This species is closely allied to *E. rathieri* d'Orbigny (Koby, 1896, p. 12, pl. 7, figs. 6, 6a), from the Hauterivian of Auxerre (Yonne), from which it differs by its slightly smaller, less protuberant corallites, better-developed second-cycle septa and greater budding angle of the corallites. *E. gemmans* de Fromentel (1870, p. 380, pl. 75, fig. 2) from the Hauterivian near Auxerre, is an even more closely related form with slightly larger calices, thicker branches and slightly more protuberant corallites.

Genus STYLANGIA de Fromentel, 1857

STYLANGIA LADDI Wells, n. sp.

Plate 70, figures 7–9; plate 71, figure 1

Corallum phaceloid, forming small tufts about a decimeter across; colony formed by extratentacular budding, new corallites being budded off about 3.5 mm. apart, mostly from one side of the parent stem at about 45°. Corallites cylindrical, 2–to 4 mm. in external diameter (a few up to 6 mm.), 1 to 2 mm. in internal diameter, projecting from the general surface of the branch as much as 4 mm. Walls thickened by peritheca, the surface of which is minutely granulated, the costae probably visible only at calyx rim. Septa hexamerally arranged in 3 complete cycles in mature corallites. Those of the first cycle are thick and reach the columella, to which they are attached by the internal marginal denticulations, which are about 0.5 mm. apart. Septa of the second cycle free on their inner margins, thin, extending about halfway to the columella. Third-cycle septa also internally free, weakly developed, extending less than half as far as the secondaries. Interior of corallite free of stereome except peripherally in old individuals. Endotheca very sparse.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. Three specimens (Holotype, U.S.N.M. no. 547388; paratypes, nos. 547389, 547390).

Remarks.—In very large corallites of this species traces of a fourth complete cycle of septa are buried in the peripheral stereome layers. The external form and relations of the corallites are not well shown by the material at hand, but there is no evidence of budding from more than the one side of a branch. *S. anomalos* (Felix) (1891, p. 162, pl. 23, figs. 4, 4a–c) from the Aptian (Barremian ?) of the Tehuacan region, southern Mexico, is a closely related species with close-set corallites arranged in four series along one side of the branch and calices

whose largest size is commonly less than the average minimum size of those of *S. laddi*. The arrangement of the corallites along the branches is subject to much individual variation and is a specific criterion of little or no value. In *S. neocomiensis* de Fromentel (Koby, 1896, p. 11, pl. 2, fig. 8) from the Hauterivian at Gy (Hte.-Saone) has branches arranged in a single plane—*espalier*—, often subplane, fused, rather than in fasciculate clumps, and the corallites are smaller: septa 6/6; corallites 1–1.5 mm.; branches 5–8 mm. thick.

Suborder FUNGIIDA
Superfamily AGARICIOIDAE
Family CALAMOPHYLLIIDAE
Genus CALAMOPHYLLIA de Blainville, 1830

CALAMOPHYLLIA SANDBERGERI Felix, 1891

Plate 71, figures 2, 3; plate 74, figures 1, 5

Calamophyllia sandbergeri FELIX, 1891, Palaeontographica, vol. 37, p. 153, pl. 22, fig. 9.
Diplarea venezuelensis GREGORY, 1927, Geol. Mag., vol. 64, p. 441, pl. 13, figs. 1a (1b?).

Corallum phaceloid, probably forming fasciculate clumps 1–2 decimeters in size by intratentacular polycentric budding of corallites at about 45°, permanent condition of corallites monocentric. Normal corallites cylindrical, but compressed, elliptical, or trilobate in section if budding, externally finely costate, ranging in diameter from 5 to 15 mm., averaging about 8 mm. Wall externally thickened, with occaasional perforations, composed essentially of a single ring of synapticulae. Septa thin, appearing laminar, with some perforations in those of higher cycles and near the columella. Number of septa varying with the size of the corallites: 4 by 6.5 mm., 56 to 60 septa; 5 mm., 38 to 44 septa; 6 mm., 56 septa; and up to about 70 in the largest budding corallites about 8 by 15 mm. in size. Cyclical arrangement of septa irregular, and about half of them reach the columella, which is loose, trabecular, moderately developed and occupying about one-fourth the axial space. Endothecal dissepiments present peripherally, thin and irregular.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela; seven specimens (U.S.N.M. nos. 547387, 547390, 547393, 547394, 547399, 547401, 547402). "Urgonian" (probably upper Barranquin formation) near Port Piritú, west of Barcelona, State of Anzoátegui, northeastern Venezuela; (*Diplarea venezuelensis* Gregory 1927). Aptian (Barremian ?), Tehuacan region, southern Mexico (Felix, 1891).

Remarks.—The new material of this species consists of many poorly-preserved fragments of corallites or bits of branches mixed with similarly fragmentary debris of *Elasmophyllia tolmachoffana* and *Thecosmilia cumanensis*. The reference to Felix' species is fairly certain in spite of his rather incomplete description and inadequate figure. Gregory's figures and description of *Diplarea venezuelensis* are poor—his figure 1b may be *Thecosmilia cumanensis* rather than *D. venezuelensis*, and his specimens seem to have averaged somewhat larger than those described above. His reference to *Diplarea* is not borne out by his figures. From what can be made out the septa are not composed of compound trabeculae, but are typical of those found in the calamophylliids.

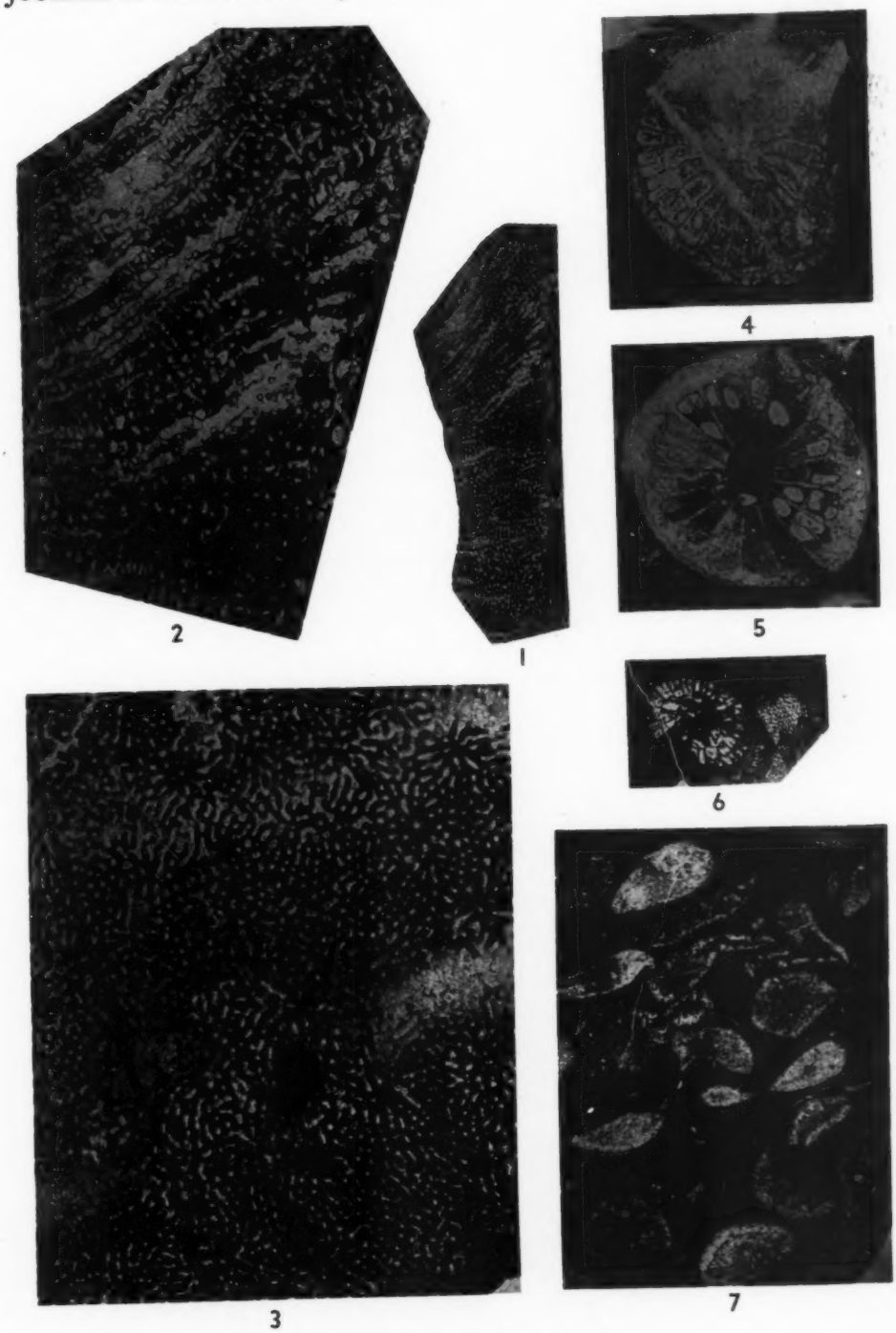
The nearest allied species is *C. compressa* d'Orbigny (Koby, 1897, p. 39, pl. 9, figs. 2, 3, 4) from the Urgonian of Europe, which has corallites of the same size but with proportionally more septa.

C. sandbergeri also occurs in an excellent state of preservation in the Lower Cretaceous limestones at Swiss River, Trinidad, associated with a coral fauna soon to be described by the writer.

EXPLANATION OF PLATE 73

FIGS. *1–3*—*Dendraraea anzoateguensis* Wells, n. sp. *1, 2*, Vertical sections, holotype, ×2½, ×5.4; *3*, transverse section, ×5.4, (547396). (Coral structures are white). (p. 440)

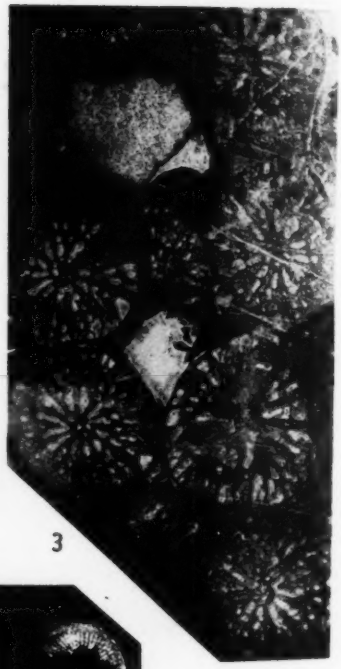
4–7—*Thecosmilia cumanensis* Wells, n. sp. *4, 5*, Transverse sections of corallites of holotype, ×5.4, (547397); *6*, transverse section of paratype corallite, with adherent *Stromatopora venezuelensis?*, ×2½, (547390); *7*, transverse section of holotype, ×2½. Many corallites are more or less crushed. (p. 441)



Wells, Venezuelan Corals

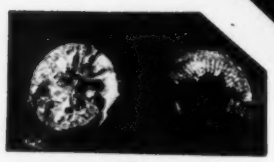
1

2

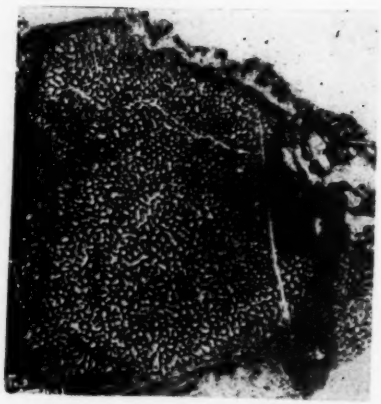


3

4



5



6

7

8

9

Wells, Venezuelan Corals

Genus PERISERIS Ferry, 1870
PERISERIS IRREGULARIS (Felix), 1891
Plate 71, figure 4

Siderofungia irregularis FELIX, 1891, Palaeontographica, vol. 37, p. 151, pl. 22, figs. 12, 12a.
Siderofungia irregularis, WELLS, 1932, Jour. Paleontology, vol. 6, p. 250, pl. 35, fig. 3; pl. 39, fig. 2.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela; one specimen (U.S.N.M. no. 547383). Upper Aptian, Tehuacan region, southern Mexico (Felix, 1891). Lower Glen Rose formation (lower Albian) Hays and Comal Counties, central Texas (Wells, 1932).

Remarks.—The single small fragment referred to this species shows no significant divergences from the Mexican and Texan specimens. It is in good condition internally and the thin section shows the simple septal trabeculae, very light synapticulotheca, thin endothecal dissepiments, and weak columella. The septa taper inwardly more than in the Glen Rose and Mexican specimens, and the corallites are slightly larger in diameter.

Superfamily PORITOIDAE
Family MICROSOLENIDAE
Genus MEANDROPHYLLIA d'Orbigny, 1849
MEANDROPHYLLIA PLUMMERI Wells, 1932
Plate 71, figures 5–7

Meandraraea plummeri WELLS, 1932. Jour. Paleontology, vol. 6, p. 251, pl. 35, fig. 1; pl. 39, figs. 7, 8.

Occurrence and material.—Chimana formation, La Borracha Island, off Guanta coast, State of Anzoátegui, northeastern Venezuela; one specimen (U.S.N.M. no. 547391). Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela; one specimen (U.S.N.M. no. 547392). Lower Glen Rose formation (lower Albian), Blanco and Hays Counties, central Texas (Wells 1932).

Remarks.—The specimen from the Chimana formation represents a fragment of an expanded laminar corallum perhaps a decimeter across, fixed by a thick peduncular base. In all particulars the structures correspond with those of the Glen Rose specimens.

The species from the Lower Cretaceous of the Tehuacan region of southern Mexico originally referred to *Latimaeandra* by Felix in 1891 were later placed by him (1914, pp. 59–60) in *Latimaeandraraea* (= *Meandrophyllia*): *L. steini* (p. 147, pl. 23, figs. 1, 1b), in which the series are much longer and slightly wider, with proportionally fewer septa (11 or 12 in 5 mm.) than *M. plummeri* (15 to 19 in 5 mm.); *L. sauteri* (p. 148, pl. 23, fig. 2), in which the series are shorter and broader, circumscribed by high collines, and irregularly meandroid rather than subparallel as in *M. plummeri*—occasionally more than a single series of centers is enclosed within the same collines (comoseroid); *L. tulae* (p. 149, pl. 24, figs. 3, 3a), which has a columniform growth form, with mostly monocentric and relatively few polycentric corallites, the latter forming very short series with high, sharp collines, narrower than in *M. plummeri*. *L. montezumae* (p. 148, pl. 22, fig. 10) does not have the habit of *Meandrophyllia*, and until the septal structure is studied it cannot be placed with any certainty, although if the structures are microsolenid, as might be inferred from Felix' (1914) reference of the species to *Latimaeandraraea*, it is a *Microsolena*.

EXPLANATION OF PLATE 74

FIGS. *1*—*Thecosmilia cumanensis* Wells, n. sp., *Elasmophyllia tolmachoffana* Wells, *Calamophyllia sandbergeri* Felix, and *Actinaraea arborescens* (Felix). Transverse section, ×2½, (547387). (p. 441)

2, 3—*Cladophyllia stewartae* Wells, n. sp. *2*, Lateral aspect of part of weathered holotype corallum, ×0.9, (547398); *3*, transverse section of holotype, ×5.4. (p. 442)

4, 5—*Budaia felixi* Wells, n. sp. *4*, Transverse section of paratype, ×2½, (547395); *5*, transverse section of holotype, ×2½, (547390). *Calamophyllia sandbergeri* with adherent *Stromatopora venezuelensis?* at right of *5*. (p. 442)

6, 7—*Stromatopora venezuelensis* Wells, n. sp. Tangential and vertical sections of holotype, ×5.4, (547382). (p. 443)

8, 9—*Halimeda*, n. sp. Transverse sections of a segment, ×5.4, (547397). (p. 444)

MEANDROPHYLLIA CARIACOENSIS
Wells, n. sp.
Plate 71, figures 8, 9

Corallum forming small, expanded, meandroid colonies by intratentacular intramural budding. Corallites in short, discontinuous series, 2 to 3.5 mm. in width between the low, rounded collines, 7 to 12 mm. in length. Septa microsolenid in structure, 24 to 30 being grouped around well-defined centers, 12 to 15 in 5 mm. along collines, subequal in thickness, higher cycles uniting with lower ones in monocentric corallites. Columella parietal, weakly developed.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. Three specimens (holotype—U.S.N.M. no. 547393; paratypes—547394, 547402).

Remarks.—Although the specimens are fragmentary and in many respects unsatisfactory, the species represented is sufficiently distinguished by its narrow valleys and proportionally larger number of septa from any of the other American species previously referred to under *M. plummeri*, and it is accordingly named. It is closely allied to *M. maeandroides* (Koby) (1898, p. 85, pl. 20, figs. 3–6) from the Urgonian of Morteau (Doubs), having about the same number of septa on the collines, slightly narrower valleys (Koby gives their width as 4 to 5 mm., but in his figures they measure only 3 to 4 mm.) and different growth habit.

Family ACTINACIDIDAE
Genus ACTINARAEA d'Orbigny, 1849
ACTINARAEA ARBORESCENS (Felix), 1891
Plate 72, figures 1–5; plate 74, figure 1

Thamnoseris arborescens FELIX, 1891, Palaeontographica, vol. 37, pl. 25, figs. 11, 15.

Corallum ramose, forming large fasciculate heads composed of upright columniform, cylindrical, or compressed branches 8 to 25 mm. in diameter, from 2 to 10 mm. apart. The holotype is 12 cm. in height and 14 by 20 cm. horizontally. Calices distinct, separated, moderately deep, circular to subpolygonal in outline, 2 to 3 mm. in diameter, 3 to 3.5 mm. between centers. Septa commonly in three complete hexameral cycles (6/6/12), those of the higher cycles uniting to those of lower and with the septa of the first cycle reaching the columella. Septa fenestrate in structure, composed of 3 to 5 simple trabeculae. Columella a single tubercle. Septocostae between corallites present with vertical trabecular elements well developed, mostly confluent but tending in places to be vague and to form a reticulate coenenchymatous meshwork.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela; three specimens (U.S.N.M. nos. 547395, 547387, 547402). Aptian (Barremian ?), Tehuacan region, southern Mexico (Felix, 1891).

Remarks.—This species was based by Felix on fragments of branches that were slightly smaller than those of the nearly complete colony described above. In practically every respect the Venezuelan specimens correspond with Felix' description, except that he indicates the number of septa to range from 24 to 40. Because of the extension of the bifurcated outer ends of the septa into the septocostal coenenchymatal complex the number of septa may easily be overestimated.

The only other species of this genus now known definitely is the genotype, *A. granulata* (Münster), from the Upper Jurassic of Europe. *A. arborescens* has smaller corallites with septocostae less clearly differentiated than *A. granulata*. *Thamnoseris*, in which Felix placed this species originally, is a synonym of *Thamnasteria*, which has septal structures quite different from those of the Actinacididae. *Actinaraea* is regarded by the writer as bridging the gap between the noncoenenchymatous microsolenids and the coenenchymate early poritids.

Genus DENDRARAEA d'Orbigny 1849
DENDRARAEA ANZOATEGUENSIS Wells, n. sp.
Plate 73, figures 1–3

Corallum small and nodular, several centimeters in diameter. Colony formed by intratentacular budding, probably polystomodaeal. Corallites weakly individualized, about 1 mm. in diameter, with centers 2 to 3 mm. apart. All structures light and strongly perforate. Corallite walls scarcely developed,

composed of a single irregular synapticular ring. Twelve septa commonly around each center, although the number may be one or two less than 12, composed of 2 or 3 trabecular pillars united by irregularly spaced synapticulae, joined irregularly to each other or to the columella. Septocostae reduced to a reticular coenenchyme, in which the vertical elements are very weak, giving a horizontally layered aspect in vertical sections. Columella composed of one or two trabecular pillars. Endothecal and exothecal dissepiments weakly developed, thin and tabular.

Occurrence and material.—Chimana formation, La Borracha Island, off Guanta coast, State of Anzoátegui, northeastern Venezuela. One specimen (holotype—U.S.N.M. no. 547396).

Remarks.—Species of *Dendraraea* and *Actinaraea*, occupying as they do an intermediate position between the microsolenids and the better-defined actinacidid genera, are difficult to place satisfactorily. The present species, based upon a small piece of a corallum, is referred to *Dendraraea* rather than to *Actinaraea* on the basis of the greatly reduced septocostae and horizontally layered appearance of the resultant coenenchyme. In *Actinaraea* the septocostae are somewhat reduced but yet mostly distinct and the vertical structures are well developed, with the result that the coenenchyme is a reticular meshwork. That it is not *Microsolena* is indicated by the individualization of the centers by a feeble synapticulotheca and the splitting of the septa across this structure.

The structures of *D. anzoateguensis* closely parallel those of *D. racemosa* (Michelin), the genotype, from the French Upper Jurassic, homeotype specimens of which were studied by the writer in the Collection Michelin in the Paris Museum. *Thamnaraea*, whose genotype, *T. digitalis* Etallon from the upper Oxfordian of Europe, is congeneric with *D. racemosa*, is represented by at least two Lower Cretaceous species: *T. holmoides* Felix (1891, p. 143, pl. 22, figs. 1, 1a) from the Tehuacan region, southern Mexico, and *T. cancellata* Koby (1898, p. 86, pl. 20, figs. 7–10) from France. In *D. holmoides* the centers are more widely separated than in *D. anzoateguensis* and there are apparently about twice as many septa; *D. cancellata* may be allied to the Venezuelan species, the only notable difference, on the basis of Koby's description and figures, being the more closely set centers of the European species.

Suborder FAVIIDA
Family MONTLIVALTIIDAE
Subfamily MONTLIVALTIINAE
Genus THECOSMILIA Milne-Edwards and Haime, 1848

THECOSMILIA CUMANENSIS Wells, n. sp.
Plate 71, figure 2; plate 73, figures 4–7; plate 74, figure 1

Colonial, forming phaceloid clumps or heads a decimeter or more in height and breadth by intratentacular budding, permanent condition monocentric. Corallites cylindrical, ranging in diameter from 6 to 8 mm., externally costate. In many corallites the exterior, as seen in section, appears smooth, indicating the presence of an epitheca over the septothecal wall. Septa thin, laminar, laterally lightly granulated or spinulose, the interspaces between them greater than their thickness, ranging in number from 36 to 48, usually nearer the latter figure, alternating regularly in length, the longer and slightly thicker ones extending to the axis of the corallite, the shorter and thinner ones usually reaching less than halfway. Columella absent although the inner margins of a few septa may meet and tangle in the axial space. Endotheca well developed, forming a peripheral zone near the wall when seen in transverse section.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. Five specimens (holotype—U.S.M.N. no. 547398; paratypes—nos. 547387, 547390, 547399, 547402).

Remarks.—The specimens occur in worn blocks of limestone, and little of the external details of the corals is shown. There has also been some lateral compression and distortion of most corallites. Two other occurrences of this genus have been recorded in the Lower Cretaceous of the Americas: *T. cf. T. tobleri* Koby, 1897, by Gregory (1927, p. 440) from the Lower Cretaceous (upper Barranquin formation?) at Port Piritú,

State of Anzoátegui, northeastern Venezuela; and *T.* sp. by Wells (1932, p. 240, pl. 30, fig. 3) from the lower Glen Rose formation (upper Aptian) in Hays County, central Texas. From both of these the new species differs by its much smaller corallites and fewer septa.

Subfamily LASMOGYRINAE
Genus ELASMOPHYLLIA d'Achiardi, 1875
ELASMOPHYLLIA TOLMACHOFFANA (Wells), 1932
Plate 72, figures 6–8

Aplosmilia? tolmachoffana WELLS, 1932. Jour. Paleonology, vol. 6, p. 234, pl. 30, fig. 2; pl. 31, fig. 2.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela, four specimens U.S.N.M. nos. 547387, 547393–547395). Lower Glen Rose formation (lower Albian), Comal and Hays Counties, central Texas (Wells, 1932).

Remarks.—The present material, consisting of fragments of branches imbedded in limestone blocks and studied mainly by thin sections, corresponds closely to the Texan material, and little can be added to the writer's previous description. One specimen (pl. 72, fig. 7) indicates the presence, in uneroded corallites, of a thin epitheca over the costae. The number of septa differs considerably from corallite to corallite: about 45 in a corallite 8 by 9 mm., 30 in one 8 by 10 mm., 38 in one 8 by 9 mm., and between 60 and 70 in an unusually large one 13 by 15 mm.

The writer's previous dubious reference of this species to *Aplosmilia* is here changed to *Elasmophyllia*. This new placing is more certain, for *E. tolmachoffana*, with its epitheca and unthickened costae, is not a rhipidogyrid but an early lasmogyrid.

Family FAVIIDAE
Subfamily FAVIINAE
Genus CLADOPHYLLIA Milne-Edwards and Haime, 1851
CLADOPHYLLIA STEWARTAE Wells, n. sp.
Plate 74, figures 2, 3

Corallum phaceloid, colony formed by intratentacular budding. Corallites cylindrical, erect, long, separated by interspaces narrower than their diameters, which average 3 mm. (maximum, 4 mm.), with well-developed epithecal walls, which unite the outer ends of the septa. Septotheca not developed. Septa very thick, strongly granulated laterally, united peripherally by thick dissepiments and the epitheca, 24 in number. Those of the first two cycles (12) are equal and meet in the axial space to form a very small, but often solid, parietal columella; those of the third cycle are about one-third as long as those of the first two, but nearly as thick. The septal interspaces are much narrower than the septa.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. One specimen (holotype—U.S.N.M. no. 547398).

Remarks.—This species is distinguished from *C. furcifera* Roemer (1888, p. 8, pl. 1, figs. 4a, 4b), from the Edwards limestone (middle Albian) of central Texas, by its longer but considerably smaller corallites. The corallites are similar in form to those of *C. miroi* Felix (1891, p. 153, pl. 25, figs. 10, 10a) from the Aptian (Barremian?) of the Tehuacan region of southern Mexico, but with larger corallites and a better-developed columella. *C. clemencia* de Fromentel (1873, p. 416, pl. 75, fig. 3) from the Hauterivian at Saint-Dizier (Hte.-Marne), has smaller calices (1.5 to 2 mm.) with fewer (18) septa; *C. crassilamella* de Fromental (1873, p. 416, pl. 93, fig. 1), from the same horizon at Morancourt, has corallites of about the same size, but with slightly more septa and a dendroid rather than phaceloid growth form. *C. tobleri* Koby (1891, p. 42, pl. 7, figs. 4, 5) from the Swiss Neocomian, has much larger (5 mm.) corallites.

Suborder CARYOPHYLLIIDA
Superfamily FLABELLOIDAE
? Family AMPHIASTREIDAE
Genus BUDAIA, Wells, 1932
BUDAIA FELIXI, Wells, n. sp.
Plate 74, figures 4, 5

Corallum solitary, cylindrical or scolecoid, or possibly forming small subfasciculate tufts by extratentacular "pocket budding,"

Wall epithecal, externally marked by concentric growth lines. Septa 12 in number, subequal, very thick at the outer ends and tapering to a thin edge inwardly, extending about two-thirds of the distance to the axis, appearing wedge-shaped in transverse section. One septum often extending well across the axis. Columella absent. Endothecal dissepiments well developed, probably in three zones. Height of corallum several cm., diameter 6 to 7 mm.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ciebas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Veneuzela. Two specimens (holotype, U.S.N.M. no. 547390; paratype, no. 547395).

Remarks.—This form differs from the genotype, *B. travisensis* Wells (1933, p. 148, pl. 2, figs. 1–5; pl. 5, figs. 6–8), from the Buda limestone (Cenomanian) of central Texas, by its smaller corallites with 12 nearly equal septa. In *B. travisensis* there are regularly 16 alternating septa. Unfortunately no satisfactory longitudinal section could be obtained from the available material to determine the arrangement of the dissepiments in more detail.

Class HYDROZÒA
Order STROMATOPOROIDEA
(Stromatoporoid group)
Family STROMATOPORIDAE
Genus STROMATOPORA Goldfuss, 1829
(*sensu lato*)
STROMATOPORA VENEZUELENSIS Wells, n. sp.
Plate 71, figures 2, 3; plate 73, figure 6; plate 74, figures 6, 7

Coenosteum encrusting, with low columniform or digitate proliferations. Presence or absence of mamelons not determined but probably absent. Astrorhizae feebly developed, very small. Structures trabecular, more vermiculate than reticulate. Vertical elements more prominent, dominant in vertical sections, discontinuous, about 0.06 mm. in thickness, 0.09 to 0.12 mm. apart. Horizontal elements equally thick and distinct but relatively fewer than verticals, to which they are fused to form a vermicular meshwork in tangential section. Tabulae very thin, arched upwards, discontinuous laterally, about 5 per mm. vertically.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. Three specimens (holotype, U.S.N.M. no. 547382; two doubtful specimens, nos. 547390, 547399).

Remarks.—This is the first record[5] of stromatoporoids in the American Lower Cretaceous, but they are probably more widespread in the Lower Cretaceous reef facies than this sole record indicates. The holotype specimen only is certainly referred to *Stromatopora*. The other specimens, found in thin sections, are very thin encrustations of a stromatoporoid on the exterior of scleractinian corallites. Their structures are very light and delicate compared with the type of *S. venezuelensis* and may well represent another genus and species.

The holotype is a part of a very small colony, and little but the internal structures can be seen. The horizontal and vertical elements, whose microstructure cannot be determined because of recrystallization, are only about half as thick, as in other Upper Jurassic and Lower Cretaceous species of this genus except *S.* (*Parastromatopora*) *minutissima* Yabe and Sugiyama (1935) p. 180; pl. 45, fig. 4; pl. 47, figs. 1–3; pl. 57, fig. 8) from the Upper Jurassic Torinosu limestone of Japan. This last may be allied to the Venezuelan form but seems to have had an exclusively encrusting growth habit.

A NEW SPONGE AND AN ALGA FROM THE BARRANQUIN FORMATION

The material described below was found in thin sections made for the study of the scleractinians and hydrozoa of the Barranquin formation. Further search failed to turn up more complete specimens, but because a record of their occurrence makes more complete our knowledge of the Urgonian reef fauna of this formation, they are herewith described.

[5] *Actinostromaria dehornae* Wells 1934 is from the Middle Cretaceous (Cenomanian) Buda limestone of central Texas.

Phylum PORIFERA
Class CALCISPONGIAE
Order PHARETRONES
Genus CORYNELLA Zittel, 1878
CORYNELLA? AGUILERAE Wells, n. sp.
Plate 75, figures 1, 2

Sponges simple, depressed-globular, broadly attached basally, commonly to a scleractinian coral. Holotype 9 mm. in maximum diameter, 8 mm. in height. Surface with small circular ostia about 0.2 mm. in width, and small irregular apertures between the fibers. Osculum 2 mm. in diameter; cloacal tube elongate infundibuliform, extending to the base, its wall nearly solid and with two or three large excurrent canals opening into it basally. Openings into excurrent canals and cloaca very few, about 0.15 mm. in width. Radial canals 0.5 mm. in diameter, their courses not determined. Skeletal fibers 0.15 to 0.25 mm. in thickness, forming an open and irregular meshwork. Spicules not observed.

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. One specimen (holotype, two thin sections, U.S.N.M. no. 547390).

Remarks.—The generic position of this little sponge can not be settled until better specimens are obtained, but it groups with *Peronidella*, *Eusiphonella*, and *Corynella*. In *Peronidella* a distinct canal system is absent; in *Eusiphonella* radial canals are arranged in vertical rows and open directly into the cloaca; and in *Corynella* the branching radial canals unite in larger excurrent canals that open into the cloaca. In *C.? aguilerae*, known only from thin sections, the course of the radial canals, which are definitely present, is not clearly shown, but the large basal excurrent canals leading to the cloaca probably connect with them.

Sponges of this type are not unknown in the Mexican Lower Cretaceous. Aguilera (1906) lists 9 species, probably all new, of *Peronidella*, *Corynella*, *Discoelia*, etc., from the region of Tehuacan, but none of them has ever been described or figured. Recently Müllerreid (1934, p. 63) referred again briefly to these and noted a single specimen, probably of *Peronidella*, from the San Antonio Texcala beds (Aptian), adherent on a coral. It is undoubtedly allied to similar forms in the European Cretaceous, such as *C. neocomiensis* (d'Orbigny) (Cottreau, 1935, p. 47; 1937, pl. 76, figs. 17–22) which is very common in the French and Swiss Hauterivian.

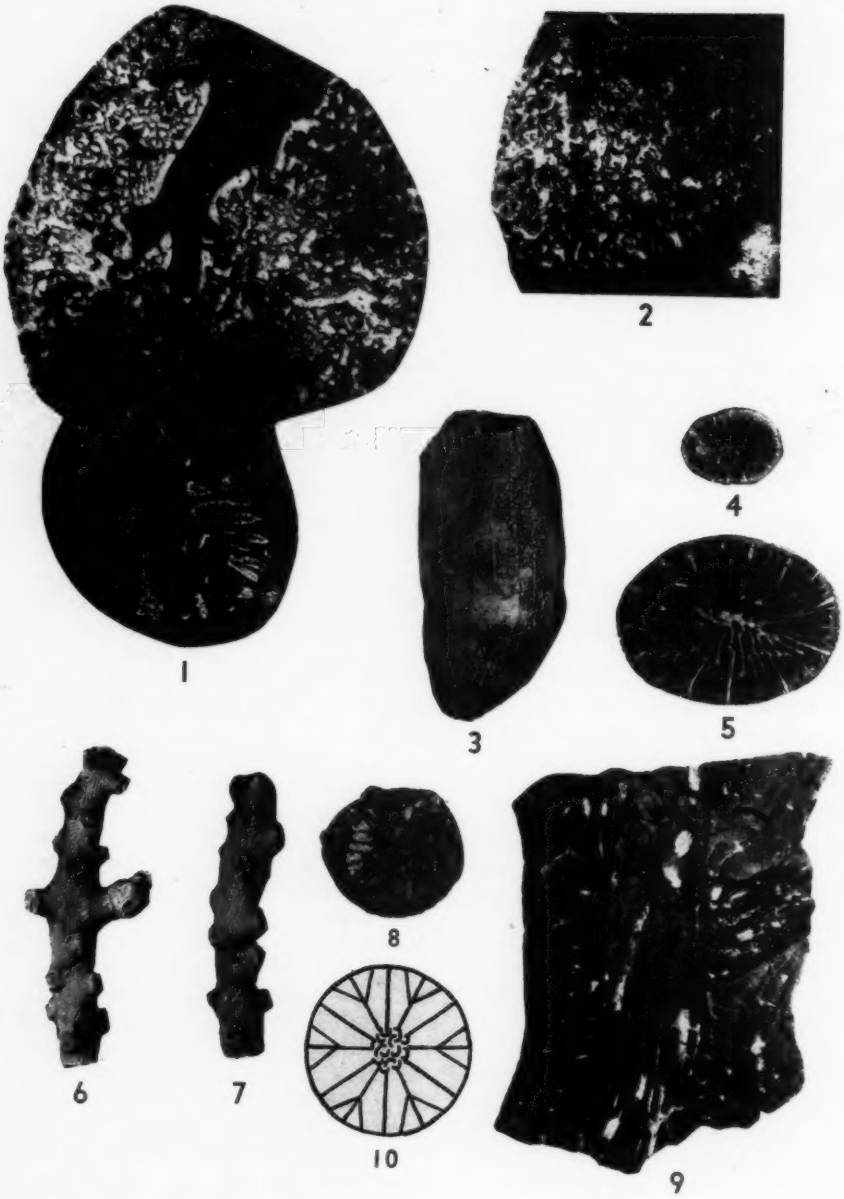
PLANTAE
Class CHLOROPHYTA
Family CODIACEAE
Genus HALIMEDA Lamouroux, 1812
HALIMEDA, n. sp.
Plate 74, figures 8, 9

Occurrence and material.—Upper Barranquin formation, at Las Cinco Ceibas, about 10 km. south of Cumaná on road to Cumancoa, State of Sucre, northeastern Venezuela. One specimen (two thin sections, U.S.N.M. no. 547398).

Remarks.—The lone specimen was found in a thin section of the holotype of *Thecosmilia cumanensis*, It represents a nearly transverse section of a compressed segment that had been washed in among the fasciculate corallites of that species. Little or nothing is known of the shape of the segment and no other specimens have been found, hence the species is not named at this time. The structures, as indicated by section, are typical of *Halimeda*. They consist of a central bundle of tubules of the central ramified filaments, a subcortical layer of the tubules of the lateral filaments, and an outer cortical layer traversed by the ultimate ramifications of the lateral filaments.

Halimeda is widespread in Tertiary and Quarternary deposits of tropical-reef facies, and is abundant and important in the tropical-reef environments of the present day. It has not hitherto been found in rocks older than Eocene, so far as the writer is aware, and its occurrence in the Barranquin formation therefore extends its known range back into the Lower Cretaceous.

Boueina Toula (1884, p. 1319, pl. 5, fig. 10; pls. 7–9), from the Neocomian of Bulgaria, is allied to *Halimeda* but seems to have consisted of solid, fingerlike thalli, rather than the dendritic articulated segments of *Halimeda*. The compressed shape of the Venezuelan specimen and its extension in the matrix for a total of only 5 or 6 mm. above and below the planes of the two



Wells, Venezuelan Corals

UNIV. OF MICH.

thin sections, clearly indicates a segment rather than part of a thumblike thallus.

TERTIARY CORALS

Family CARYOPHYLLIIDAE

Genus CARYOPHYLLIA Lamarck, 1801

CARYOPHYLLIA CLAVUS Scacchi, 1835

Plate 75, figures 3–5

For partial synonymies see Felix (1927, pp. 418–419), and Doederlein (1913, p. 112).

Occurrence and material.—Lower Carapita shale (Hedberg and Pyre, 1944, p. 22) Santa Inés formation, middle Oligocene, Rio Capiricual, State of Anzoátegui, northeastern Venezuela. Six specimens (U.S.N.M. no. 547403).

Remarks.—This well-known species, which is very widely distributed in present seas in depths of 20 to 1250 fathoms, has been adequately described by several workers, expecially Doederlein (1913, pp. 112–116, pl. 7, figs. 3–20). It has not been previously reported as fossil from the Americas, nor elsewhere from formations older than middle Miocene, but there appears to be no reason to doubt the identity of these Venezuelan Oligocene specimens. They all have the cornute, elongate corallum with oval calyx and small base, and more than four cycles of septa arranged in three series characteristic of the species. The preservation of the specimens is poor, and the shape and size of the pali can not be made out.

Dimensions.—

	Height	*Calyx*	*Septa*	
Venezuela	16 mm.	10 by 14 mm.	72	(18/18/36)
Venezuela	19	11 by 14	64	(16/16/32)
Venezuela	41	13 by 20	80	(20/20/40)
Recent, Bay of Naples	—	12 by 16	72	(18/18/36)

Family DENDROPHYLLIIDAE

Genus DENDROPHYLLIA de Blainville, 1830

DENDROPHYLLIA ARAGUENSIS Wells, n. sp.

Plate 75, figures 6–10

Dendroid, with slender, subcylindrical branches, which form acute angles of about 60° with the main stem, averaging 5.5 mm. in diameter, tapering slightly, smaller branches down to 2 mm. in diameter. Calices shallow, with thin margins, circular, small, ranging from 2 to 2.5 mm. in diameter, projecting as much as 3.5 mm. above the coenenchyme, roughly spiral in arrangement, spaced 4 to 5 mm. apart except near the tips of the branches, where the interval is somewhat less. Calices inclined toward the extremities of the branches. Septa 24 in number, in three complete cycles, moderately thick, laminar and very rarely with perforations. Those of the first cycle are free and extend to the columella; those of the second cycle equal those of the first and also meet the columella, joined about one-third the distance inward from the wall by the septa of the third cycle. Substitution of the septa marked in the last two cycles. Columella well developed, trabecular, about one-third the diameter of the corallite. Corallite wall thin at the calices, partly synapticulothecate and partly formed by septal thickening. Costae well developed, low, broad, gently rounded and finely granulated, more or less vermiculate, united by regularly spaced synapticulae and thickened considerably by stereome in thicker parts of branches. The pores between the synapticulae remain open, however, and the coenenchyme does not become solid with age.

Occurrence and material.—In a dark-gray, partly indurated clay from a well core (depth 7111–7131 feet) in the Santa Inés (middle Oligocene-middle Miocene) formation (Carapita shale?), in the Aragua district, State of Anzoátegui, northeastern Venezuela. One specimen representing many

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EXPLANATION OF PLATE 75

FIGS. *1, 2—Corynella? aguilerae* Wells, n. sp. Longitudinal and tangential sections of holotype, ×6, (547390). Specimen is adherent to corallite of *Thecosmilia cumanensis*. (p. 444)

3–5—Carophyllia clavus Scacchi. Middle Oligocene. *3*, Lateral aspect of large corallum, ×1; *4, 5*, polished transverse sections of smaller coralla, ×1, ×2½, (547403). (p. 445)

6–10—Dendrophyllia araguensis Wells, n. sp. Oligocene or Miocene. *6, 7*, Branches of holotype, ×2; *8, 9*, transverse and longitudinal sections, ×6; *10*, diagram of septal plan, ×6, (547404) (p. 445)

fragments from the same colony (holotype, U.S.N.M. no. 547404).

Remarks.—Dendrophyllia is not a common genus in the American Tertiaries, and at present it is not known to be living in the Caribbean area. The present species is marked by the small size of the branches and calices. The fragile aspect of the corallum, together with the small number of septa, more porous coenenchyme, and rounded rather than acute costae, distinguish it from *D. peruviana* Vaughan (1922, p. 134, pl. 23, figs. 3, 3a). *D. lisbonensis* Vaughan (1900, p. 191, pl. 22, figs. 20–20c), from the lower Claibornian of the Gulf Coast, may be a related species, but has more septa and more closely set calices, *D. hannibali* Nomland (1916, p. 67, pl. 6, figs. 1–3), from the middle Oligocene of Chehalis County, Washington, has a more openly branched growth form with larger calices and more septa. The same distinction applies to *D. californiana* Nomland (1917, p. 188, pl. 5, figs. 6, 6b) from the Oligocene of California. *D. taurinensis* Milne-Edwards and Haime (1848, p. 99), from the Miocene of Italy, has much larger branches and calices, as does also *D. digitalis* de Blainville (1830, p. 320) of the French Miocene.

RECENT CORALS FROM PUERTO LA CRUZ

Specimens of recent reef-building corals were dredged several years ago from the harbor of Puerto La Cruz, between Barcelona and Cumaná, on the Caribbean coast of Venezuela. According to Dr. Hedberg,

> The immense amount of coral rock which was dredged up at this time included no living coral so far as I know. There have been extensive changes in sea level and coastal configuration in very recent times in this area, and such changes are probably responsible for the fact that this reef, although of recent age, was entirely dead. A few kilometers away from the mainland and in the vicinity of the numerous small islands which surround the Puerto La Cruz bay there is an abundance of living coral, which can readily be seen through the clear water surrounding these islands. (Personal communication.)

Corals are everywhere sparse along the Caribbean coast of South America, and the writer knows of no published records of species from the Venezuelan part of the continental coast. For this reason, it is desirable to place on record the following list of species, all of them well-known West Indian forms:

HERMATYPIC CORAL SPECIES FROM PUERTO LA CRUZ, U.S.N.M. NOS. 547405–547417

Stephanocoenia michelini Milne-Edwards and Haime (*Astrea intersepta* Lamarck, 1816, *et auct.*, not *Madrepora intersepta* Esper 1797).

Acropora prolifera (Lamarck).
Siderastrea siderea (Ellis and Solander).
Porites furcata Lamarck.
Montastrea cavernosa (Linnaeus).
Montastrea annularis (Ellis and Solander).
Diploria strigosa (Dana).
Colpophyllia natans (Müller).
Eusmilia fastigiata (Pallas).
Meandrina meandrites (Linnaeus).

Dichocoenia stokesi Milne-Edwards and Haime. Normal specimen with calices rarely less than 4 mm. in diameter (smaller ones are immature); another specimen with very closely set calices rarely more than 3 mm. in diameter. The latter seems to represent *D. stellaris* M.-E. and H., a very rare form that probably should be considered a subspecies of *D. stokesi*.

Oculina cf. *O. diffusa* Lamarck. Two specimens, neither of which has the typical habitus of this, the common West Indian reef-dwelling species of *Oculina*. Both have anastomosing branches that average 12 mm. in diameter in one specimen and 6 mm. in the other, somewhat greater than in typical *O. diffusa*, and both have smaller, more widely spaced calices. At least 9 other "species" of *Oculina* have been named from the Western Atlantic and West Indian areas, most of these probably being merely ecologic variants of *O. diffusa*. The one which the specimens from Puerto La Cruz most closely approximate is *O. valenciennesi* M.-E. and H., as described by Verrill (1901, p. 176, pl. 32, fig. 5). The two specimens are local or individual variants of one species, and the smaller-branched one in many respects approaches *O. diffusa*.

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OSTRACODA FROM THE REKLAW EOCENE OF BASTROP COUNTY, TEXAS

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ABSTRACT—Sixteen species of Ostracoda, five of which are new, are described and figured from the Reklaw Eocene, Claiborne group of Texas. The species were taken from a single locality near the town of Smithville, Bastrop County, Texas.

AN INVESTIGATION of the microfauna of the Reklaw formation has been prompted by the considerable amount of recent drilling in Texas which has penetrated the lower Claiborne and Wilcox Eocene strata. The faunal content of the Reklaw is of particular interest, occurring as it does in the lowermost marine member of the Claiborne group. The unfossiliferous Carrizo formation below, with often many hundreds of feet of the older Wilcox sediments carrying little or no fauna, add to the difficult task of paleontological correlation in this part of the subsurface section.

A rather sparse foraminiferal fauna occurs in the outcrop Reklaw of Bastrop County. The forms present are somewhat dwarfed but appear to be identical or closely allied to species in the younger Weches formation. Identification of the Reklaw on the basis of Foraminifera is thus extremely difficult, and cores from the formation in the subsurface carry very few if any Foraminifera.

Ostracoda are not uncommon in the surface exposure, and while rare in the subsurface, they are usually present. Of the 16 species included in this study, nine have been found to range upward into the Weches formation at the exposure at Smithville, Bastrop County, Texas. Three of these species lived on into Jackson Eocene time. Four of the species occur in the older Wilcox Eocene, and six have been identified only from the Reklaw.

My thanks are extended to J. B. Garrett and C. F. Washburn, of the Stanolind Oil and Gas Company, Houston, Texas, who collected the outcrop Reklaw material used in this study. Type specimens upon which the species are based will be deposited in the Louisiana State University Museum, Baton Rouge, Louisiana.

The specimens here described were collected at an exposure of the Reklaw formation, Claiborne Eocene, in Ridge Creek, which lies 6.2 miles west of the town of Smithville, on a gravel road to the small settlement of Upton (see Bastrop quadrangle), Bastrop County, Texas. Ridge Creek crosses the road about 0.8 miles east of Upton. The road crosses the creek on a small concrete bridge, and a high railroad trestle is beside it. Ridge Creek is intermittent but has a deep course, steep sides, and it meanders considerably. It apparently is not named on the Bastrop quadrangle. The locality is almost a mile upstream (southwest) from the road crossing, at a prominent bluff. The upper 20–25 feet consist of very gypsiferous gray to brown shale. Below this is a dark-greenish-gray very glauconitic fossiliferous clay.

Sample A.—Dark thin-bedded shale in lower part of unfossiliferous section. Examination of this sample disclosed a single species of Foraminifera, *Cyclammina* sp., to be the only form in the microfauna.

Sample B.—Dark-greenish-gray very glauconitic fossiliferous clay, taken 6 feet below sample A, and almost at top of fossiliferous section.

Sample C.—Same lithology, 2 feet below sample B, and just below a thin ironstone layer.

Sample D.—Same lithology, 5 feet below sample C, and 100 yards downstream.

Sample E.—Same lithology, 5 feet below sample D, downstream.

Sample F.—Same lithology, 3 feet below sample E. The section is becoming unfossiliferous in this sample, which carries a very sparse fauna of only a few species of Ostracoda and Foraminifera, together with rare Mollusca.

SYSTEMATIC DESCRIPTIONS

Family CYTHERELLIDAE

Genus CYTHERELLA Jones, 1849

CYTHERELLA sp.

Occasional specimens of what appears to be a single species of *Cytherella* occur in the Reklaw material. Although somewhat smaller, they appear to be indistinguishable from *Cytherella fimbricinctus* Sutton and Williams (1939, p. 562, pl. 64, figs. 14, 15) in the Weches formation, Claiborne Eocene. The authors of the Weches species have failed, however, to note any characteristic for differentiating it from any other, and I doubt whether *C. fimbricinctus* is a valid species. My specimens are likewise very similar to *Cytherella* sp. of Howe and Chambers (1935, p. 6, pl. 4, figs. 17, 18; pl. 5, figs. 11, 12) from the Jackson Eocene at Montgomery, Louisiana. Due to the generalized character of the Reklaw specimens, it seems unwise to describe the species or to assign it to a described form, especially as it lacks any stratigraphic significance.

Length of a typical specimen 0.64 mm.; height 0.41 mm.; width 0.28 mm.

Genus HAPLOCYTHERIDEA Stephenson, 1936

HAPLOCYTHERIDEA HABROPAPILLOSA
Sutton and Williams
Plate 76, figure 4

Cytheridea mülleri (Münster). STADNICHENKO (part), 1927, Jour. Paleontology, vol. 1, p. 238. pl. 39, figs. 14–17 (not fig. 13).
Cytheridea (*Haplocytheridea*) *habropapillosa* SUTTON and WILLIAMS, 1939, Jour. Paleontology, vol. 13, p. 570, pl. 64, figs. 20–22.
Cytheridea (*Haplocytheridea*) *habropapillosa*, STEPHENSON, 1942, Jour. Paleontology, vol. 16, p. 107, pl. 18, figs. 21, 22.

Typical specimens of this species occur in the outcrop Reklaw from Bastrop County. Described from the Weches formation at Smithville, Texas, the species has also been reported (Stephenson, 1942, p. 107) from the Cook Mountain formation of the Texas Claiborne Eocene.

Length of a right valve (including spines), 0.71 mm.; height, 0.37 mm.; length of a left valve, 0.76 mm.; height, 0.42 mm.

Types.—Hypotypes, nos. 2371, 2372, from sample E.

HAPLOCYTHERIDEA LISBONENSIS
Stephenson
Plate 76, figure 12

Cytheridea (*Haplocytheridea*) *lisbonensis* STEPHENSON, 1942, Jour. Paleontology, vol. 16, p. 108, pl. 18. figs. 11, 12.

This species was described from the Lisbon formation, Claiborne Eocene of Alabama. The occurrence of specimens in the Weches and Cook Mountain formations of the Texas Claiborne was indicated at that time (Stephenson, 1942, p. 109). It is also present, though very rare, in the Cane River formation, Claiborne Eocene of Natchitoches Parish, Louisiana. Entirely typical specimens occur in the Reklaw, although the species is rare.

Length (right valve), 0.70 mm.; height, 0.39 mm.; length (left valve), 0.69 mm.; height, 0.42 mm.

Types.—Hypotypes, nos. 2373, 2374, from sample C.

HAPLOCYTHERIDEA STENZELI
Stephenson
Plate 76, figures 17–20

Cytheridea (*Haplocytheridea*) *stenzeli* STEPHENSON, 1942, Jour. Paleontology, vol. 16, p. 482, text figs. 1–3.

Previously described by me (Stephenson, 1942a), the primary type specimens of this species were taken from the same material upon which the present report is based, and the specimens are herein refigured. The species is rather common in the Reklaw of Bastrop County.

Length of holotype, 0.77 mm.; height, 0.45 mm.; width, 0.42 mm.

Types.—Holotype, no. 2295; paratypes nos. 2296, 2297. All specimens are from sample C.

Genus CLITHROCYTHERIDEA
Stephenson, 1936

CLITHROCYTHERIDEA GARRETTI
(Howe and Chambers)
Plate 76, figure 1

Cytheridea? garretti HOWE and CHAMBERS, 1935, Louisiana Dept. Cons. Geol. Bull. 5, p. 14, pl. 1, figs. 4, 5; pl. 2, figs. 11, 12; pl. 6, figs. 10, 11.

Cytheridea (Clithrocytheridea) garretti, STEPHENSON, 1936, Jour. Paleontology, vol. 10, p. 702, pl. 94. figs. 5, 6, 10; text figs. 1 *l*, *o*, *p*.
Cytheridea (Clithrocytheridea) garretti, STEPHENSON, 1942, Jour. Paleontology, vol. 16, p. 110, pl. 18, fig. 1.

This species was originally described from the Cocoa sand (of C. W. Cooke) of the Jackson Eocene, near Water Valley, Alabama. In addition to Jackson Eocene occurrences, the form has been reported by me (Stephenson, 1942, p. 110) from the Lisbon formation, Claiborne Eocene of Alabama. No specimens are present in my collections from the Weches formation of Bastrop County, Texas, and it is exceedingly rare in the Reklaw. A comparison of Reklaw specimens with topotypes of the species from the type locality in Alabama shows the Reklaw form to be identical but much smaller. The length of the holotype was given as 0.83 mm., which is about an average size of Jackson specimens.

Length (left valve), 0.53 mm.; height, 0.31 mm.

Types.—Hypotype, no. 2375, from sample D.

Genus CYTHEREIS Jones, 1849

CYTHEREIS HILGARDI Howe and Garrett

Plate 76, figure 11

Cythereis hilgardi HOWE and GARRETT, 1934, Louisiana Dept. Cons. Geol. Bull. 4, p. 53, pl. 4, figs. 14, 15.

Carapace subrhomboidal, somewhat higher anteriorly. Anterior end broadly and obliquely rounded, bearing blunt spines, which are more prominent toward the ventral margin. Posterior end lower, pointed, denticulate on its ventral half. Dorsal and ventral margins nearly straight and converging somewhat toward the posterior, often in part obscured by surface ornamentation. Eyespot rather small but distinct, from which a strong marginal rim extends around the anterior end, the rim having a sharp crest except where broken by short spines toward the ventral margin. A short distance behind the eyespot a spinose ridge follows and obscures the dorsal margin, abruptly angling vertically downward a short distance at the posterocardinal angle, where it forms a crested projection. A short, slender, spinose, horizontal ridge occupies a median position posterior to the center, with a depressed area anterior to it and separating it from an irregular, closely grouped clump of spines. A lower carinate, fluted, faintly spinose ridge extends downward in a concave arc, at times partially obscuring the ventral margin. Remainder of carapace wall is covered with scattered short, rather slender spines, between which is a reticulate pattern of low, intersecting ridges.

Length (right valve), 0.75 mm.; height, 0.42 mm.; length (left valve), 0.79 mm.; height, 0.45 mm.

Remarks.—A comparison of my material with topotype specimens of *C. hilgardi* from the Wilcox Eocene at Sabinetown, Texas, indicates some specimens with nearly identical ornamentation. The figured specimen is somewhat more strongly sculptured than those from the Wilcox, with more of a development of spines and a more prominent oblique vertical projection below the posterior cardinal angle. It seems impractical to separate the more highly ornamented form.

Cythereis florienensis Howe and Chambers from the Jackson Eocene is a more elongate, more compressed species, with the dorsal ridge lacking, and in its place several spines projecting above the dorsal margin.

The species is rare in the Reklaw.

Types.—Hypotypes, no. 2376, from sample D; no. 2377, from sample B.

CYTHEREIS MONTGOMERYENSIS Howe and Chambers

Plate 76, figure 7

Cythereis montgomeryensis HOWE and CHAMBERS, 1935, Louisiana Dept. Cons. Geol. Bull. 5, p. 37, pl. 1, figs. 13, 16; pl. 2, figs. 22, 23; pl. 6, figs. 19, 20.
Cythereis quinquespinosa SUTTON and WILLIAMS, 1939, Jour. Paleontology, vol. 13, p. 566, pl. 63, figs. 10, 11.

This rather generalized, spinose species of *Cythereis* was described from the Jackson Eocene at Montgomery, Louisiana. The number, arrangement, and prominence of the spines on specimens from the type locality is quite variable. The "short, vertically oblique row of spines situated just in front of the posterior cardinal angle" (Howe and Chambers, 1935, p. 37) is present on some specimens from Montgomery and absent from others. Specimens without this row of

spines were not considered to be specifically distinct from those exhibiting this feature, and it seems impractical to separate them. The form described from the Weches, Claiborne Eocene, as *Cythereis quinquespinosa* Sutton and Williams appears to be identical with the Jackson species. Numerous specimens are present in the Reklaw, showing the same variations as those in the Jackson Eocene.

Length (right valve), 0.85 mm.; height, 0.50 mm.; length (left valve), 0.79 mm.; height, 0.50 mm.

Types.—Hypotypes, nos. 2378, 2379, from sample C.

CYTHEREIS REKLAWENSIS Stephenson, n. sp.
Plate 76, figure 14

Carapace elongate, subrhomboidal, greatest height at the anterior cardinal angle. Anterior end broadly and evenly rounded, faintly spinose. Posterior end angular, pointed well above the middle, armed with short spines on ventral portion. Dorsal and ventral margins straight, subparallel, converging slightly toward the posterior. A rather heavy angular rim extends inside and subparallel to the anterior margin from the obscure eyespot. A rounded ridge is visible along most of the dorsal margin, curving downward at its ends. A second horizontal, somewhat undulating ridge across the center of the carapace merges with an irregular thickened area of the shell wall. A third ridge near the ventral margin is concave toward the dorsal margin in its anterior half, convex in its posterior portion. Areas between ridges irregularly excavated, the depressions carving into flanks of the ridges.

Length (right valve), 0.82 mm.; height, 0.39 mm.; length (left valve), 0.90 mm.; height, 0.46 mm.

Remarks.—This species has been observed by me only in the Reklaw formation. It is a very rare form.

Types.—Syntypes, nos. 2380, 2381, from sample B.

CYTHEREIS RUSSELLI Howe and Garrett
Plate 76, figure 15

Cythereis? russelli HOWE and GARRETT, 1934, Louisiana Dept. Cons. Geol. Bull. 4, p. 54, pl. 4, fig. 11.

Cythereis fragillissima SUTTON and WILLIAMS, 1939, Jour. Paleontology, vol. 13, p. 565, pl. 63, figs. 21, 22.

Described from the Wilcox Eocene at Sabinetown, Texas, this species is very rare in the Reklaw. It is impossible to distinguish topotypes from Sabinetown from specimens referred to *C. fragillissima* in the Weches formation by Sutton and Williams, although most Wilcox specimens are somewhat larger.

C. deusseni Howe and Chambers (1935, p. 27, pl. 1, fig. 15; pl. 6, figs. 2, 3), from the Jackson Eocene, is very similar, but has a much more fragile carapace, more delicate ornamentation, and small, distinct eyespot, and a lower, less prominent posterior cardinal angle.

Length (right valve), 0.70 mm.; height, 0.36 mm.

Types.—Hypotype, no. 2382, from sample B.

CYTHEREIS ELMANA Stadnichenko
Plate 76, figure 13

Cythereis elmana STADNICHENKO, 1927, Jour. Paleontology, vol. 1, p. 240, pl. 39, fig. 20.
Cythereis sinuata SUTTON and WILLIAMS, 1939, Jour. Paleontology, vol. 13, p. 565, pl. 63, figs. 15–17.

Occasional specimens referable to this species occur in the Reklaw material, where the species is fairly typical except for a break in the anterior lobe ornamenting the shell wall.

Length (right valve), 0.84 mm.; height, 0.44 mm.

Types.—Hypotype, no. 2383, from sample B.

CYTHEREIS UPTONENSIS Stephenson, n. sp.
Plate 76, figure 9

Carapace small, elongate, subquadrate, highest anteriorly. Anterior end broadly and evenly rounded, armed with fine, short spines; posterior end narrower, compressed, bluntly angular. Dorsal and ventral margins nearly straight, converging somewhat toward the posterior. Eyespot small, rather obscure, a slender, keellike marginal rim extends from it around the anterior end, with the shell wall excavated inside it. A low, thickened rim outlines the posterior

end. A narrow rounded ridge parallels the dorsal margin and abruptly angles downward onto the shell wall a short distance at the posterior cardinal angle. Inside and subparallel to the ventral margin is a shorter, less prominent ridge. Remainder of carapace wall is smooth.

Length, 0.43 mm.; height, 0.23 mm.; thickness, 0.18 mm.

Remarks.—A similar form occurs in the Weches at Smithville, Texas. The Weches specimens appear to be larger, with a less carinate anterior rim, and the ventral ridge is lacking.

C. uptonensis is quite rare in the Reklaw.

Types.—Holotype, no. 2384, from sample C.

CYTHEREIS WASHBURNI Stephenson, n. sp.
Plate 76, figure 8

Carapace subrhomboidal, highest on the anterior. Anterior end broadly and evenly rounded, armed with numerous fine, blunt spines. Posterior end bluntly pointed, spinose on its ventral half like the anterior. Dorsal margin nearly straight, sloping gently toward the posterior. Ventral margin somewhat convex, bearing a number of blunt spines. A prominent spherical eyespot is visible. Exterior strongly and intricately sculptured. A pronounced marginal rim inside and paralleling the anterior end has a number of irregularly disposed prominent spines along its crest. Entire surface covered with numerous spinose projections, each coalesced at the base and tending to divide into several short spines at its end. Area between spines consists of a reticulate pattern of slender lower ridges enclosing shallow angular pits between them.

Length (right valve), 0.73 mm.; height, 0.42 mm.; length (left valve), 0.70 mm.; height, 0.43 mm.

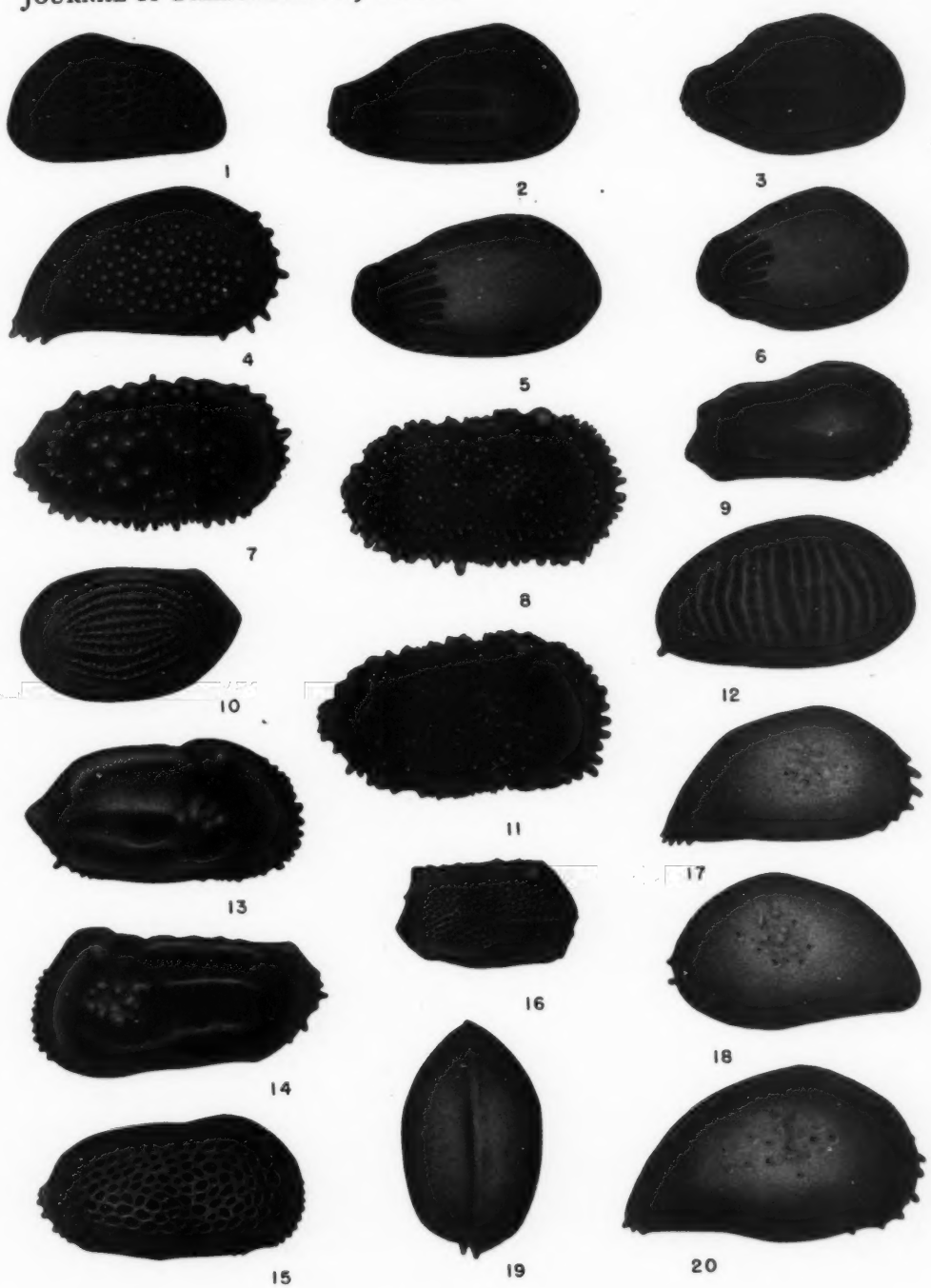
Remarks.—*C. washburni* is easily identifiable because of its strong ornamentation. The sculpturing is often somewhat masked, however, by matrix clinging to the carapace even after thorough washing.

The species should not be confused with *C. smithvillensis* Sutton and Williams (1939, p. 564), a fairly common form in the Weches formation. The Weches species is larger and proportionally more elongate, with less sculpturing. Beautifully preserved specimens of *C. smithvillensis* from Smithville, Texas, fail to show that "sharp and delicate spines have been broken off, leaving their bases as a network of intersecting ridges" (Sutton and Williams, 1939, p. 564). Rather than this, the majority of specimens of the Weches species appear to show a reticulate pattern of low intersecting ridges as the dominant ornamentation. The scattered spines are quite short, and less conspicuous and fewer in number than on *C. washburni.*

Types.—Syntypes, no. 2385, from sample C; no. 2386, from sample E.

EXPLANATION OF PLATE 76

FIGS. *1*—*Clithrocytheridea garretti* (Howe and Chambers). Left valve, ×60. (p. 449)
2, 3—*Pyricythereis alabamensis* (Howe and Pyeatt). *2*, Right valve view of a male. *3*, Right valve view of a female. ×55. (p. 453)
4—*Haplocytheridea habropapillosa* Sutton and Williams. Right valve, ×60. (p. 449)
5, 6—*Pyricythereis seminuda* Stephenson, n. sp. *5*, Right valve view of a male. *6*, Right valve view of a female. ×55. (p. 453)
7—*Cythereis montgomeryensis* Howe and Chambers. Right valve, ×45 (p. 450)
8—*Cythereis washburni* Stephenson, n. sp. Right valve, ×55. (p. 452)
9—*Cythereis uptonensis* Stephenson, n. sp. Right valve view, ×75. (p. 451)
10—*Loxoconcha delicata* (Sutton and Williams). Left valve, ×75. (p. 454)
11—*Cythereis hilgardi* Howe and Garrett. Right valve, ×55. (p. 450)
12—*Haplocytheridea lisbonensis* Stephenson. Right valve, ×55. (p. 449)
13—*Cythereis elmana* Stadnichenko. Right valve, ×45. (p. 451)
14—*Cythereis reklawensis* Stephenson, n. sp. Left valve, ×45. (p. 451)
15—*Cythereis russelli* Howe and Garrett. Right valve, ×55. (p. 451)
16—*Eucytherura claibornensis* Stephenson, n. sp. Right valve, ×85. (p. 453)
17–20—*Haplocytheridea stenzeli* Stephenson. *17*. Right valve. *18*, Left valve. *19*, Dorsal view. *20*, Right valve view. Figs. *17–19*, ×45; *20*, ×55. (p. 449)



Stephenson, Eocene Ostracoda

UNIV. OF MICH.

Genus PYRICYTHEREIS Howe, 1936

PYRICYTHEREIS ALABAMENSIS (Howe and Pyeatt)

Plate 76, figures 2, 3

Cythereis? alabamensis HOWE and PYEATT, 1934, *in* HOWE and GARRETT, Louisiana Dept. Cons. Geol. Bull. 4, p. 50, pl. 4, figs. 2, 5, 7–10.

Pyricythereis subtriangularis SUTTON and WILLIAMS, 1939, Jour. Paleontology, vol. 13, p. 569, pl. 64, figs. 11–13.

This species, attributed to Howe and Pyeatt, was included in a report on Wilcox Eocene Ostracoda by Howe and Garrett (1934).

Some variation in the degree and pattern of ornamentation is seen in this species. At some Wilcox localities in Louisiana, the species appears identical with specimens from the Reklaw, but at others it is more finely ribbed. Wilcox specimens from Alabama show a variant in the pattern of ridges, which cover nearly the entire carapace. *P. alabamensis* is well developed in the Weches, Claiborne Eocene of Texas, from which it was described as *P. subtriangularis* by Sutton and Williams (1939). Weches specimens are somewhat larger in the adult than those in the Reklaw, but agree in all other shell characters.

Length (male), 0.64 mm.; height, 0.35 mm.; width, 0.31 mm.; length (female), 0.56 mm.; height, 0.35 mm.; width, 0.30 mm.

Remarks.—*P. alabamensis* shows fairly strong lateral ridges, a feature which readily distinguishes it from *P. israelskyi morsei* (Howe and Pyeatt) from the Jackson Eocene (see Howe and Chambers, 1935, p. 34, pl. 3, figs. 11, 12). The Jackson form shows rather small, closely spaced pits, but with no trace of ridges.

Types.—Hypotypes, nos. 2387, 2388, from sample E; nos. 2389, 2390, from sample C.

PYRICYTHEREIS SEMINUDA Stephenson, n. sp.

Plate 76, figures 5, 6

Carapace rather small, elongate, subovate, highest anterior to the middle. Anterior end broadly and obliquely rounded; posterior end narrower, in the left valve compressed and produced around the prominent posterocardinal angle. Dorsal and ventral margins somewhat convex, more strongly so in the larger left valve, and converging toward the posterior. Anterior half of the valves slightly compressed, with an inflated area of the shell wall in the posterior half. Carapace smooth on about the anterior two-thirds. At about one-third the shell length from the posterior, a variable number of about six usually well incised grooves extend in a more or less horizontal course toward the posterior. Between the grooves are slender ridges, which become obscure toward the posterior end.

Length (male), 0.64 mm.; height, 0.36 mm.; width, 0.32 mm.; length (female), 0.53 mm.; height, 0.35 mm.; width, 0.31 mm.

Remarks.—This species bears some resemblance to *P. israelskyi* (Howe and Pyeatt) in the Jackson Eocene (see Howe and Chambers, 1935, p. 33, pl. 1, figs. 19–21; pl. 4, figs. 7–9). *P. seminuda* shows no trace, however, of the "cross-riblets" which tend to form a reticulate pattern on the ornamented portion of the Jackson species. The new species is likewise more strongly sculptured on the ornamented portion.

Types.—Holotype, no. 2391; paratypes, nos. 2392–2396, all from sample C.

Genus EUCYTHERURA Müller, 1894

EUCYTHERURA CLAIBORNENSIS Stephenson, n. sp.

Plate 76, figure 16

Carapace small, subquadrate. Dorsal margin straight, sloping very gently toward the posterior, and subparallel to the slightly convex ventral margin. Anterior end rounded; posterior end bluntly angular, sloping abruptly and steeply from the prominent posterocardinal angle. Surface strongly sculptured, showing small, deep, closely spaced pits, which cover the entire exterior except for the short, blunt posterior caudal process, which is nude. A small elevated eyespot is visible. Shell wall compressed along the dorsal margin, with a depressed area extending through the central portion toward the ventral margin. Hinge structure similar to that in the genus *Cythereis*.

Length (right valve), 0.30 mm.; height, 0.17 mm.

Remarks.—This species is exceedingly rare in the Reklaw. It seems worthy of mention, as there are so few records of the genus in the Gulf Coast Tertiary.

Types.—Holotype, no. 2397, from sample C.

Genus LOXOCONCHA Sars, 1865
LOXOCONCHA DELICATA (Sutton and Williams)
Plate 76, figure 10

Pyricythereis delicata SUTTON and WILLIAMS, 1939, Jour. Paleontology, vol. 13, p. 568, pl. 64, figs. 5–7.

This species was erroneously assigned to the genus *Pyricythereis* by Sutton and Williams (1939), in their report on the Ostracoda of the Weches formation. Ornamentation of specimens from the Reklaw is very similar to that exhibited by topotypes from the Weches. Sculpturing of the species is somewhat variable in both formations, but it does not seem feasible to attempt the separation of a new species. A number of Reklaw specimens are more delicately ornamented than the average of those from the Weches. *L. delicata* appears to be distinct from all species of this genus described by Murray (1938) from the Claiborne Eocene.

Length (right valve), 0.45 mm.; height, 0.25 mm.; length (left valve), 0.42 mm.; height, 0.25 mm.

Types.—Hypotypes, nos. 2398, 2399, from sample C.

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JOURNAL OF PALEONTOLOGY, VOL. 18, NO. 5, PP. 455–463, PL. 77, 1 TEXT FIG., SEPTEMBER 1944

PERMIAN TRILOBITES FROM WESTERN AUSTRALIA

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With an appendix by C. J. Stubblefield

ABSTRACT—The few trilobites which have so far been found in the Permian rocks of Western Australia all belong to the genus *Ditomopyge*, which is briefly discussed. It is proposed to retain the name for species that belong to an evolutionary stage intermediate between *Griffithides* and *Pseudophillipsia*. The Western Australian species, which occur in two different stratigraphical series, are somewhat intermediate between typical *Ditomopyge* and typical *Pseudophillipsia*. One specimen retains color markings, which are different from any previously described in trilobites.

INTRODUCTION

TRILOBITES are of rare occurrence in the Permian, although they are represented by a greater variety of forms than is usually supposed. Fortunately the trilobites of the Carboniferous and Permian periods have been discussed in some detail in recent years by Weber (1933), Toumansky (1935), Weller (1936), and Gheyselinck (1937), so that it is now possible to gain a fairly good idea of the distribution and composition of Permian trilobite faunas.

It seems that the following generic names have been applied to trilobites of Permian age:

Phillipsia Portlock, 1843
Griffithides Portlock, 1843
Pseudophillipsia Gemmellaro, 1892
Cheiropyge Diener, 1893
Anisopyge Girty, 1908
Noeproetus Tesch, 1923
Ditomopyge Newell, 1931
Cyphinium Weber, 1933
Permoproetus Toumansky, 1935
Neogriffithides Toumansky, 1935
Paraphillipsia Toumansky, 1935

There are differences of opinion as to the latitude that should be allowed some of the genera, but Weller and Gheyselinck agree that *Cyphinium* Weber must be regarded as a synonym of *Ditomopyge* Newell; also, *Pseudophillipsia* Gemmellaro and *Anisopyge* Girty are often regarded as synonyms. After the elimination of *Cyphinium* and *Anisopyge* from the above list we are left with nine genera of trilobites that have been reported from Permian beds. Of these *Cheiropyge* probably belongs to the family Otarionidae, all the other genera to the family Proetidae.

Gheyselinck has thoroughly discussed all of these genera and questioned the validity of some of them. In his opinion *Neogriffithides* and *Paraphillipsia* are not sufficiently different from *Phillipsia* Portlock to allow of their separation as independent genera. In the same way he proposed to suppress *Neoproetus* as a synonym of *Griffithides* Portlock and *Ditomopyge* as a synonym of *Pseudophillipsia*. *Permoproetus* is reduced to the rank of a subgenus of *Proetus* Steininger. Thus in Gheyselinck's arrangement *Neogriffithides*, *Paraphillipsia*, *Neoproetus*, and *Ditomopyge* are removed from the list of Permian trilobites, reducing the number of trilobite genera and subgenera in the Permian to five.

Permian trilobites have so far been reported from the United States (California, Texas, Kansas), from Sicily (Sosio), the Crimea, the Urals, from a few places in the Himalayas, from Timor and neighboring islands in the East Indies, from China, and from Western Australia, that is, from a good many of the places where thick and fossiliferous Permian sections are known.[1] In other words, the trilobites were apparently quite normal, if very subordinate, members of the Permian faunas of the open shelf seas and geosynclinal areas.

It is usually assumed that Permian trilobites are little more than paleontological curiosities and that no stratigraphical value is attached to them. However, it must be re-

[1] Late Palaeozoic trilobites have also been reported from Dutch New Guinea (Martin 1911, Teichert 1928), but the specimens that have been collected up to date are very poor, and it is not known whether they are of Carboniferous or of Permian age.

membered that the trilobites of the Carboniferous were similarly regarded until recently, when Schwarzbach (1935, 1936) in Germany and Weller (1937) in North America demonstrated their usefulness for stratigraphical purposes. As our scanty knowledge of Permian trilobites increases they will undoubtedly turn out to be of some importance for correlation. It will be shown below that the trilobites found in Western Australia, in conjunction with the consideration of the associated fauna, give valuable aid to the determination of the age of the beds in which they occur.

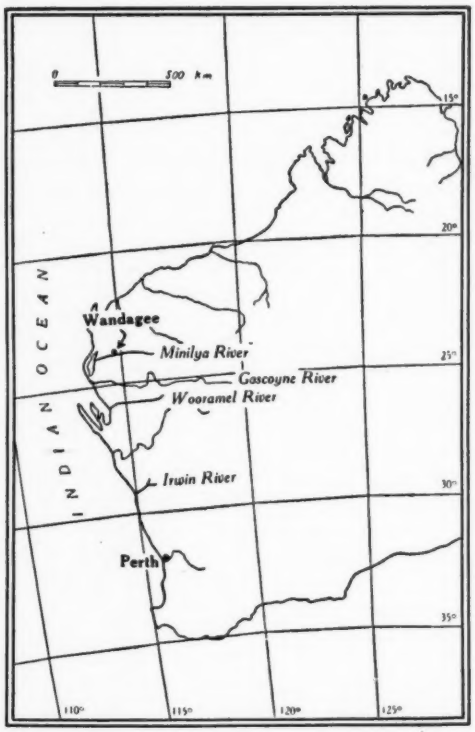

FIG. 1—Index map of Western Australia, showing principal localities mentioned in the text.

PERMIAN TRILOBITES IN WESTERN AUSTRALIA

The earliest mention of the occurrence of a trilobite in Western Australia in beds now considered to be of Permian age was made by Etheridge (1892, p. 125), who makes reference to a pygidium, "apparently a *Phillipsia*," from 25 miles west of "Coerdawandy and the Yaltra Mountains, Gascoigne River." These names are now spelt Coordawandy, Yalbra, and Gascoyne respectively, and it appears that this locality is not anywhere near the Gascoyne River at all, but somewhere not far from the Wooramel River and northeast of the Carrandibby Range about 100 miles inland from the coast and most likely in beds of the age of the Byro series. It is probably this same specimen which was listed as "*Phillipsia grandis*" from the Gascoyne River by Glauert in 1910. The specimen has never been properly studied and described.

No additional trilobites were ever mentioned in papers dealing with Western Australian late Palaeozoic fossils, and apparently no further specimens were collected until E. de C. Clarke in the years 1934–1936 undertook a number of field trips to the Irwin River District. Among the large collections secured on these occasions were three specimens of trilobites, which were sent to C. J. Stubblefield for closer examination. Circumstances have so far prevented Dr. Stubblefield from describing these finds in detail, but he has kindly given me permission to publish as an appendix to this paper his conclusion that the specimens represent one, or possibly two, new, as yet unnamed, species of the genus *Ditomopyge*.

The specimens described in the present paper come from the upper part of the Wandagee series in the North-West Division of Western Australia, from the vicinity of the Minilya River, Wandagee Station. They were obtained on field trips in 1939, 1940, and 1941 by the writer and students of the University of Western Australia, and one specimen was collected by H. Coley of Wandagee Station. All these specimens were found to belong to a new species, *Ditomopyge meridionalis*.

In addition, I describe an unnamed cranidium of a *Ditomopyge* from the Fossil Cliff limestone of the Irwin River, collected some years ago and kindly lent to me by Mr. L. Glauert of the Perth Museum. This specimen may be expected to be conspecific with the specimens now in the hands of Dr. Stubblefield.

These two occurrences of Permian trilo-

bites in Western Australia are widely separated geographically (see fig. 1) as well as stratigraphically, but both are in strata which have previously been regarded as being of Artinskian age.

DITOMOPYGE AND ITS ALLIES

The genus *Ditomopyge* was originally described by Newell (1931) on the basis of immature pygidia. A few years later Weller (1935) was able to study mature pygidia of the same genus, and he also made additions to our knowledge of the thorax and cephalon of the genus. Furthermore, he called attention to the fact that the genotype of *Ditomopyge*, *D. lansingensis* Newell, seemed to be congeneric with *Phillipsia scitula* Meek and Worthen, which Weber, in 1933, had selected as the genotype of a new genus *Cyphinium*. Both names are synonyms, and *Ditomopyge* takes priority. The genus is now particularly well known from Russia (Donetz Basin and Ural Mountains), since most of the species described under *Cyphinium* by Weber are referable to it.

As Gheyselinck (1937) has demonstrated, *Ditomopyge* belongs to the griffithid stock of late Palaeozoic trilobites and is most closely related to *Pseudophillipsia* Gemmellaro. The latter genus is distinguished from *Griffithides* Portlock by an anteriorly expanded and posteriorly shortened glabella, which is separated from the occipital ring by a broad depression, in which two basal lobes and one central ("preoccipital") lobe are situated; the posterior margin of the glabella of *Pseudophillipsia* is scalloped. In the sides of the glabella are two or three pairs of incisions or depressions, which are directed obliquely anteriorly.

Typical *Ditomopyge* differs from *Pseudophillipsia* in the absence of furrows from the glabella, in having an entire posterior margin of the glabella, and in having a narrow, instead of a broad, flattened border in front of the glabella. Also, species of *Ditomopyge* are said to possess between 7 and 22 axial segments in the pygidium, whereas in *Pseudophillipsia* this number is never less than 23 and may be as great as 30.

In 1937, Gheyselinck very thoroughly discussed the relationships between *Pseudophillipsia* and *Ditomopyge* and came to the conclusion that no clear distinction can be drawn between the two genera; that the species referred to them show complete gradation from the *Ditomopyge* to the *Pseudophillipsia* stage; and that *Ditomopyge* should, therefore, be regarded as a synonym of the latter, which he regarded as a subgenus of *Griffithides*.

Gheyselinck seems to be right in discarding differences in the number of axial segments in the pygidia as being of doubtful classificatory value. That as a rule the number of segments in trilobite pygidia is of no more than specific significance was emphasized by Raymond as early as 1921. As will be shown in the description of *Ditomopyge meridionalis* below, it seems that the number of segments on the pleural region is a more constant feature than the number of axial segments.

As regards the cephalon, Gheyselinck seems to have been the first to recognize that the furrows in the glabella of *Pseudophillipsia* are not homologous to the lateral furrows in the glabella of other trilobites. The lateral furrows having once been lost during the evolution of the griffithid branch of trilobites in the late Paleozoic can not be expected to reappear in the latest descendant of the line. The furrows in the pseudophillipsid glabella are a secondary acquisition and have the same significance as the scalloping of its posterior margin. Both are the expresion of the last specialization, or "decay," as Gheyselinck puts it, of the glabella of the griffithid stock.

Notwithstanding these observations it would seem advantageous to distinguish the fairly large number of species which represent the evolutionary stage intermediate between typical *Griffithides* and typical *Pseudophillipsia* by a separate name and it is therefore proposed to retain the name *Ditomopyge* for trilobites which, though related to those genera, have a posteriorly shortened glabella with an entire posterior border and no furrows and which have well-developed basal and median ("preoccipital") lobes.

"*Phillipsia*" *perannulata* Shumard, the genotype of *Anisopyge* Girty (1908, p. 505) can not easily be fitted into the *Griffithides-Ditomopyge-Pseudophillipsia* lineage. The glabella in that species has not been shortened to the degree noticed in typical *Ditomopyge* and *Pseudophillipsia*, as there is

no complete separation of the median, preoccipital lobe from the glabella. On the other hand the species possesses the advanced pseudophillipsid feature of the secondary lateral furrows in the glabella. Although "*Phillipsia*" *perannulata* is more similar in appearance to species of *Pseudophillipsia* than to any of either *Griffithides* or *Ditomopyge*, it seems most reasonable to assume that that species developed independently in North America out of an American griffithid stock, whereas the true *Ditomopyge-Pseudophillipsia* lineage developed only in the Eurasian seas.

Instead of combining polyphyletic species into one genus, it would be more natural to regard the American species *Phillipsia perannulata* either as a strongly specialized *Griffithides* or to retain Girty's name *Anisopyge* for it.

Ditomopyge as here understood ranges from the Middle Carboniferous to the Artinskian, and is found in North America, Russia, China, and Western Australia. The number of known trilobites from Timor has been greatly increased by Gheyselinck (1937), but they all come from the Basleo beds, which are slightly younger than Artinskian, and *Ditomopyge* is not among them.

COLOR MARKINGS

The preservation of color markings in trilobites must be extremely rare, since only three cases have as yet been put on record. One is a pygidium of *Anomocare* from the Cambrian of Alabama, described by Raymond in 1922, which showed distinct radial banding and incidentally is the oldest-known fossil retaining color markings. The second case was recorded by Williams in 1930, who described a pygidium of *Proetus* from the Mississippian of Missouri that showed two rows of subcircular spots and two rows of transverse markings on the axis. A third occurrence is that recently described by Wells (1942), of specimens of *Isotelus maximus* from the Ordovician of Ohio, which have supposed color patches in the axial furrows and on the pleura as well as on the free cheeks around the eyes and on the genal spines.

One of the pygidia of *Ditomopyge meridionalis* shows remains of color markings of a different type. Unfortunately, in this specimen (no. 21335) only part of the original test of the pygidium is preserved. The test is brownish-grey and is dotted with black spots of somewhat irregular size and shape. Most of them are between 0.1 and 0.2 mm. in diameter, but some are as large as 0.5 mm. They are densely though somewhat irregularly scattered over the surface of the pleural region as well as of the axis; there is no difference in the appearance of the markings on these two parts of the pygidium.

These color markings are more like those found in many recent Crustacea than the markings previously described by Raymond, by Williams, and by Wells. Many Decapoda have a similarly mottled color pattern on their thorax and abdomen.

The four records of trilobites with color markings which are now available seem to indicate that among the trilobites there must have been quite a variety of color patterns, in addition to many uniformly colored forms whose presence has been suspected by Raymond.

SYSTEMATIC DESCRIPTION

Genus DITOMOPYGE Newell, 1931

DITOMOPYGE MERIDIONALIS Teichert, n. sp.

Plate 77, figures 1–5, 7–12

The holotype (no. 21331) is an external mould of a cephalon and thorax. Of the cephalon the greater part of the left free cheek (with eye) and of the glabella can be seen, but the anterior outline of the cephalon is not preserved. Since the anterior part of the glabella is missing the latter looks rather flat, although actually it is strongly inflated in this species. As can be seen in another specimen, the general outline of the glabella is pyriform, and it is bounded by two posteriorly converging dorsal furrows. There are faint traces of tuberculation on the posterior part of the glabella, but this feature is much better shown in a cranidium which will be described below (no. 21334). The median (preoccipital) lobe is separated from the glabella by a distinct though shallow groove. The basal lobes are subtriangular and sharply defined. The neck furrow is about as wide as the occipital ring; the latter is narrow and strongly convex; as far as can be told it is without a median tubercle.

The facial sutures are sinuous, form strong palpebral lobes, and meet the posterior margin back of the eyes. The eyes are large, strongly elevated, their sides rising almost vertically from the free cheeks, which are produced into short and somewhat blunt genal spines.

Some measurements of the cephalic region are as follows:

Width of cephalon	26 mm.
Length of cephalon	about 10 mm.
Anterior width of glabella	9 mm.
Length of glabella	about 6–7 mm.
Posterior width of glabella	3.5 mm.
Length of basal lobes	2 mm.
Width of base of cranidium	9 mm.
Width of neck ring	2 mm.
Distance from posterior end of suture to tip of genal spine	8 mm.
Length of genal spine	3.7 mm.

The thorax is not well preserved, only parts of seven segments being visible. The axis is strongly elevated, almost semicircular in cross section. The pleura are geniculated, bending down sharply at a distance of about 3 mm. from the sides of the axis. There is no ornamentation on either the axis or the pleura.

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Length of cephalon	about 10 mm.
Anterior width of glabella	9 mm.
Length of glabella	about 6–7 mm.
Posterior width of glabella	3.5 mm.
Length of basal lobes	2 mm.
Width of base of cranidium	9 mm.
Width of neck ring	2 mm.
Distance from posterior end of suture to tip of genal spine	8 mm.
Length of genal spine	3.7 mm.

The thorax is not well preserved, only parts of seven segments being visible. The axis is strongly elevated, almost semicircular in cross section. The pleura are geniculated, bending down sharply at a distance of about 3 mm. from the sides of the axis. There is no ornamentation on either the axis or the pleura.

The pygidium is semicircular, strongly convex, with a strongly elevated axis, which reaches almost to the end of the pygidium. From the best preserved pygidia the following measurements have been taken:

Catalogue number	21332	21335	21338	21333	21336
Greatest width	16.7	16.3 (approx.)	14.2	10.8	6.8
Length	12.5	12.3	9.8	6.8	3.4
Height	4.8	5.3	?	3.5	2.0
Length of axis	11.0	11.0	8.0	5.8	2.8
Greatest width of axis	7.2	6.0	4.2	3.5	2.0 (approx.)
No. of axial segments	11	11	10	9	8
No. of pleural segments	7	7	7	7	7
Ratio of axial to pleural segments	0.636	0.636	0.700	0.777	0.875

Other specimens. In addition to the holotype one cranidium and eight pygidia or fragments of pygidia are available.

The cranidium (no. 21334) belongs to a larger specimen than the holotype; the neck ring is not preserved, but the glabella alone is 12 mm. long and 11.5 mm. wide in front. The width of the glabella at its posterior end is 4 mm. The median lobe and the basal lobes are clearly distinguished. The glabella is strongly convex in the longitudinal section; from the posterior end to the front it curves through slightly more than 90°. In the lateral section the glabella is also strongly inflated, its sides rising at steep angles from the dorsal furrows. The frontal margin of the cranidium is not well preserved, but there is evidence of a frontal brim (or limb) which slopes less steeply than the frontal portion of the glabella. The posterior part of the glabella is covered with small but distinct tubercles, which seem to be crowded into the posterolateral corners of the glabella, occupying a position approximately opposite the basal lobes. It is possible that the tuberculation extends some distance anteriorly along the sides of the glabella, but the test in these parts is not well preserved. The internal mould of the glabella shows six very faint short transverse ridges near the lateral margins of the posterior half of the glabella, reflecting apparently six very shallow furrows, which may be found on the inner side of the test of the glabella. There is no trace of either ridges or furrows recognizable on the outside of the test.

The axis has steeply inclined sides and an almost flat top. It is crossed by transverse ridges, and on each shoulder it has a row of tubercles, one pair of tubercles to each transverse ridge. The tubercles are also visible on the internal mould, though less distinct. The transverse ridges continue on the sides of the axis, but are much less prominent there. On the internal mould these lateral ridges are much more prominent and appear in almost the same strength as on the flat top of the axis.

The pleural region is flat in the vicinity of the axis but slopes at an angle of about 50° towards the margin. The lateral and posterolateral parts of this slope are very slightly concave. The pleura bear ribs, which disappear at a distance from the margin about equal to the distance between the posterior end of the axis and the posterior margin of the pygidium. The part around the posterior end of the axis is also smooth. Owing to the slight concavity of the lateral slopes of the pygidium, the smooth marginal rim seems to be slightly inflated. At the margin the sides of the pygidium curve abruptly inward to form an inner brim or doublure about 1 mm. wide. The impression of this inflected brim appears as a smooth, somewhat flattened border on the internal moulds.

Well-preserved pygidia range in size from 3.4 to 12.5 mm. in length (see table). A remarkable fact is that the number of pleural segments is constant, viz. seven, in specimens of all sizes, whereas the number of axial segments increases from eight to 11. It appears therefore that the number of pleural segments is a more constant specific feature than the number of axial segments, to which great weight has been attached by some authors. It also seems that caution must be exercised if the ratio of pleural to axial segments is used to characterize species, since this figure changes during ontogeny.

The color pattern of this species has been described in an earlier section of this paper.

Occurrences.—Specimens of *Ditomopyge meridionalis* have been found in the North-West Division of Western Australia in the upper part of the Wandagee series, mostly from approximately the *Helicoprion-Paragastrioceras* zone upwards to somewhat below the highest horizon with *Pseudogastrioceras goochi* (see Teichert, 1942, p. 223), a range of about 600 feet, but an odd specimen was found at least 1,000 feet lower down in the section, in the middle part of the *Calceolispongia* stage, thus indicating a fairly wide vertical range for the species.

All the specimens come from Wandagee Station in the North-West Division of Western Australia. The localities are: 21331 (holotype), just west of northwestern gully of Wandagee Hill on fence dividing Shed and Mungadan Paddocks, 770 yards south of northwest corner of Shed Paddock, in ferruginous sandstone (same horizon and locality as holotype of *Pseudogastrioceras goochi* Teichert); 21332, 21334, 900 to 1,100 yards N. 50°–60° E. of the place where the Wandagee Woolshed—Middalya road passes through the fence between Mungadan and Nalbia Paddocks, in Nalbia Paddock in ferruginous sandstone beds of the middle and higher *Linoproductus* stage; 21335, about 600 yards northeast of southeastern gully of Wandagee Hill, in Mungadan Paddock, just below highest horizon with *Pseudogastrioceras goochi;* 21336, southern part of Coolkilya Paddock in a sandstone horizon of the middle *Linoproductus* stage that crosses the fence between Coolkilya and Dry Paddock 1980 yards west of the S. E. corner of Coolkilya Paddock, about 75 yards north of that fence; 21337, northern part of Coolkilya Paddock, from lowest beds of *Linoproductus* stage in center of syncline north of Minilya River, about 1500 yards west of Coolkilya Pool; 21338, northern part of Coolkilya Paddock, about half a mile east-southeast of Curdamurda Mill, south bank of Minilya River, in a small syncline striking almost east and west, in sandstone of the middle *Calceolispongia* stage.

All specimens are in the Department of Geology, University of Western Australia.

Remarks.—The affinities of this species are closest with "*Cyphinium*" *artinskiense* Weber from the vicinity of Krasnoufimsk, in the southern Urals. Both species combine in a curious way primitive and advanced features, if compared with the North American lineage of *Ditomopyge*. First, as regards the length of the genal spine, which suffers gradual reduction in American species, *Ditomopyge meridionalis* is comparable to upper Pennsylvanian rather than to lower Permian species (see Weller, 1937, figs. 4 H and 4 I). Secondly, the ratio of the number of pleural segments to the number of axial segments of mature pygidia of *Ditomopyge meridionalis* (0.636) is greater than that of even upper Pennsylvanian species in North America and falls well within the range of middle Pennsylvanian forms (cf. Weller, 1937, p. 343).

The same conditions also prevail in *Ditomopyge artinskiensis*, which has a rather long spine, perhaps even longer than that of *D. meridionalis*, and in which the ratio of

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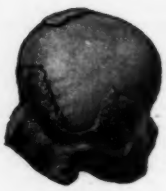

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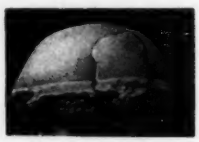

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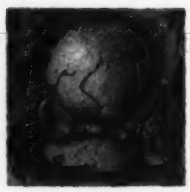

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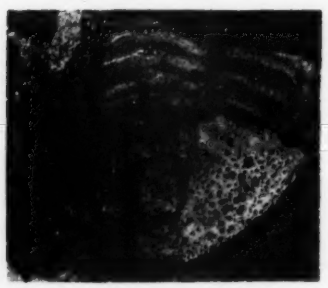

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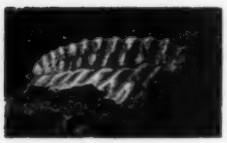

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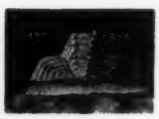

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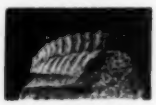

12

Teichert, Permian Trilobites from Western Australia

UNIV. OF MICH.

pleural to axial segments in the pygidium, according to Weber's observations, may be either 0.667 or 0.727, that is possibly as great as in North American lower Pennsylvanian species.

Compared with the pygidium the glabellas of both *D. meridionalis* and *D. artinskiensis* show advanced features that place them close to species of the genus *Pseudophillipsia*. Both are tuberculated near their posterior margin, but whereas in the Russian species the tubercles are arranged in a row along that margin, in *D. meridionalis* they are concentrated in two groups near the posterolateral corners of the glabella. The same is also true for *Ditomopyge* sp. from the Irwin River, to be described below.

Weber has interpreted the tuberculation of the glabella of *D. artinskiensis* as "vestiges of a scalloping which is proper to the subgenus *Pseudophillipsia*." Gheyselinck objected to the use of the word "vestige" in this connection, pointing out that we are here concerned with the initial stages of the development of a new feature, but his term "rudimentary beginning" seems unfortunate.

As far as the features of the glabella are concerned, both *D. artinskiensis* and *D. meridionalis* seem to represent perfect transition stages between earlier, typical species of *Ditomopyge* in which the posterior margin of the glabella is smooth, and *Pseudophillipsia*, which is essentially a post-Artinskian genus, reaching its main development in Sosio and in the Crimea, and in which the posterior margin of the glabella is scalloped. *Pseudophillipsia sumatrensis* (see Roemer, 1880, pl. 3, and Fliebel, 1901, pl. 8), which is probably only slightly younger than the Western Australian species, possesses a glabella with an almost smooth posterior margin but with marked lateral furrows, showing only a small advance over *Ditomopyge meridionalis* in the structure of its glabella. However, the pygidium of *Pseudophillipsia sumatrensis* is much more highly developed, having 13 pleural and 25 axial segments.

The close resemblance of *Ditomopyge meridionalis* to an Artinskian species from Krasnoufimsk serves further to emphasize the Artinskian affinities of the Wandagee fauna. Both at Krasnoufimsk and at Wandagee there is a characteristic association of closely related species of *Pseudogastrioceras*, *Paragastrioceras*, *Ditomopyge*, and *Helicoprion*.

DITOMOPYGE sp.
Plate 77, figure 6

Only one cranidium is available, which belongs to a specimen considerably larger than any of *Ditomopyge meridionalis* described above. As the anterior portion of this cranidium is destroyed, its length cannot be accurately determined. With this reservation the measurements of the specimen are as follows:

Length of cranidium	±22 mm.
Width at base	21 mm.
Length of glabella	15 mm.
Greatest width of glabella	15.5 mm.
Posterior width of glabella	5.5 mm.
Width of neck ring	4.5 mm.

The degree of curvature of the glabella in the longitudinal section can not be stated. In the transverse section the glabella is rather prominent and flat-topped, with sides steeply sloping towards the longitudinal furrows. In its posterior part the glabella bears small, somewhat irregularly arranged tubercles, which are concentrated in the posterolateral corners and along the lateral margins of the glabella, where the surface begins to slope towards the lateral furrows.

EXPLANATION OF PLATE 77

FIGS. *1–5*—*Ditomopyge meridionalis* Teichert, n. sp. From the Wandagee series. *1–4*, Cranidium, no. 21334, in two different dorsal aspects and in frontal and lateral views, ×2. *5*, Squeeze of holotype, a natural external mould, no. 21331, ×2. (p. 458)

6—*Ditomopyge* sp. Cranidium, no. 4860, from Fossil Cliff limestone, ×1. (p. 461)

7–12—*Ditomopyge meridionalis* Teichert, n. sp. From the Wandagee series. *7*, Pygidium, no. 21335, retaining color markings on its shell, ×3. *8*, *9*, Pygidium, no. 21332, dorsal and lateral views, ×2. *10–12*, Pygidium, no. 21333, dorsal, posterior, and lateral views, ×2. (p. 458)

The originals of figs. *1–5* and *7–12* are in the Department of Geology, University of Western Australia, of fig. *6* in the Western Australian Museum and Art Gallery, Perth.

Here, however, the tubercles are very faint. There is no trace of any ridges or grooves, however faint, on the internal mould of the glabella.

The preoccipital lobe behind the glabella is low and rather indistinct. It is, however, accentuated by a narrow, sharp ridge, almost short enough to be called a tubercle. The lateral lobes are triangular and somewhat more distinct that the preoccipital lobe.

The neck furrow is narrow, though rather sharply incised. The neck ring is wide and flat, rising gradually from the neck furrow towards the posterior margin of the cranidium, where it reaches its greatest elevation, equal almost to that of the posterior portion of the glabella. The neck ring does not quite extend to the posterolateral angles of the cranidium, these angles being separated by two narrow longitudinal furrows, against which the neck ring abuts.

The facial sutures are sinuous, forming strong palpebral lobes. They apparently meet the posterior margin of the cephalon at a point somewhat obliquely backward and outward from the eyes, at an angle of about 45°.

Occurrence.—Fossil Cliff limestone. Fossil Cliff, Irwin River, Western Australia. No. 4860, Western Australian Museum and Art Gallery, Perth.

Remarks: This specimen has not been referred to *Ditomopyge meridionalis*, owing to certain differences in the ornamentation of the glabella, the shape of the preoccipital lobe, and the width and profile of the neck ring, possibly also of the course of the facial sutures. It is, however, possible that these differences are not of a specific nature and may ultimately be found to be due to the greater size of the specimen from Irwin River.

It may be noted that the pygidia from the same locality (see Appendix by Stubblefield) may have as many as eight pleural segments, that is more than what appears to be the fixed number in the pygidia of *D. meridionalis*.

The evolutionary stage of the cranidium is approximately the same as that indicated by the cranidia of *D. meridionalis*, that is, its features are somewhat intermediate between *Ditomopyge* and *Pseudophillipsia*, except for the absence of faint ridges on the inner side of the test of the glabella. The significance of this feature, however, is not quite clear.

APPENDIX

PERMIAN TRILOBITES FROM IRWIN RIVER DISTRICT, WESTERN AUSTRALIA.

C. J. STUBBLEFIELD.
Geological Survey and Museum, South Kensington, London.

Material.—Two specimens, which may belong to one or perhaps two species.

Cephalon, thorax and pygidium in articulation preserved as an external mould in a silty matrix from the Irwin River.

A pygidium existing in counterpart in an argillaceous limestone also from the Irwin River.

A damaged pygidium from Beckett's Gully.

Identification.—From such features as can be seen from the cephalon, the presence of a preoccipital lobe and a straight preoccipital furrow, the specimen should be referred to *Cyphinium* Weber (1933), genotype *Phillipsia* (*Griffithides*) *scitula* Meek and Worthen, 1865. Weber made *Cyphinium* a subgenus of *Griffithides*. J. M. Weller, (1935a, p. 505) affirmed that *Cyphinium* Weber was a synonym of *Ditomopyge* Newell, 1931. Newell's genus was established on immature pygidia of *D. lansingensis* Newell, but Weller (1936, p. 711) states that since similar immature pygidia are known from three species of which adult stages exist "it is certain therefore that *Cyphinium* is an exact synonym of *Ditomopyge*."

The range of *Ditomopyge* according to Weller is lower Pennsylvanian to lower Permian of North America, Upper Carboniferous of Russia.

The Australian pygidia show a flattened crest to the axis, giving a trapezoidal cross section. This feature is stated by Weber (1933, p. 71) to appear "in the Middle Carboniferous." According to Weller (1937, p. 341), in America the feature appears in the Morrow formation (Pennsylvanian).

The Australian pygidia show 11 or 12 axial segments and 6 to 8 pleural segments. American species of *Ditomopyge* according

to Weller (1937, p. 343) are in this stage of pygidial segment development in lower-middle Pennsylvanian times. I note that Weber (1933, p. 89) has described a species of *Cyphinium artinskiense*, showing similar segmental ratios from the Artinskian of the Urals, but I should add that the cephalon of the Ural species differs noticeably from that of the Australian. I quote these last two facts to illustrate my belief that no deduction as to age should be drawn from this segmental ratio in the present case.

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JOURNAL OF PALEONTOLOGY, VOL. 18, NO. 5, PP. 464–469, PL. 78, 1 TEXT FIG., SEPTEMBER 1944

A NEW PALEOCENE GASTROPOD FROM SOUTHERN CALIFORNIA

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ABSTRACT—A new Paleocene gastropod, *Serratocerithium usanium*, n. sp., is described from the Santa Monica Mountains, California. A review of the synonymy of *Cerithium* Bruguière and *Clava* Martyn makes it reasonable to raise *Serratocerithium* to generic rank.

INTRODUCTION

THE MATERIAL described in this paper was collected by the writer during the summer of 1941 near Santa Ynez Canyon in the southwestern Santa Monica Mountains.

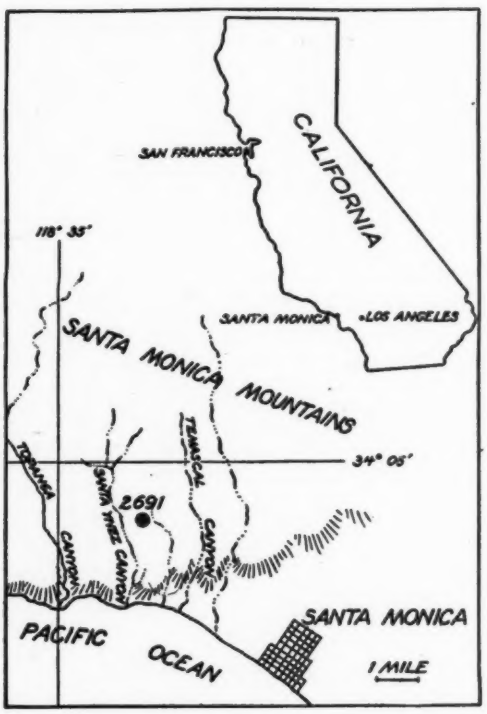

FIG. 1—Index map showing location of Stanford University Locality 2691, Los Angeles County, Calif.

The specimens are in the paleontological collections of Stanford University, California.

Thanks are due to Hubert G. Schenck and A. Myra Keen of Stanford University for assistance in the preparation of this paper; to G. F. Ferris, also of Stanford, for advice in the solution of the nomenclatural problems; to Julia Gardner of the U. S. Geological Survey, B. L. Clark of the University of California, Leo G. Hertlein of the California Academy of Sciences, and L. R. Cox of the British Museum (Natural History) for their opinions on the classification of the new species; to the Mountain Park Association for permission to use their roads and properties for collecting; and to H. H. Renz for specimens from Trinidad for comparison.

GEOLOGY

Hoots (1931) has described the geology of that part of the Santa Monica Mountains which includes the area shown on the map (fig. 1). The general structure is a large faulted anticline whose axis strikes northwest, approximately parallel with the range. The beds in which the fossils were found are part of a thick series of sediments that form most of the southern limb of the anticline. These strata, mapped by Hoots as "Undivided Chico and Martinez," are exposed over an area of about 8 square miles. They consist of a sequence of sandstones, conglomerates, shales, and algal limestones all dipping steeply to the south. According to Hoots the contacts with almost all older and younger rocks are faulted. Because of lack of time Hoots did not divide his "Chico" and "Martinez" formations on his map, but he described their probable approximate distribution by reference to fossiliferous localities and especially to the lithologic differences of the rocks. The "Chico" rocks are typically coarse conglomerates, hard gray sandstones, and dark gray shales; the "Martinez" rocks are gray to brown shales with thin beds of friable gray sandstones and

massive reefs of algal limestone. The stratigraphy of this area has not been worked out in detail.

The material described in this paper was collected at Stanford University locality 2691 in a thin calcareous sandstone interbedded with siltstones and shales. Woodring identified fossils that Hoots collected from this area as "of Martinez age" (Hoots, 1931, p. 93). It is not strictly correct, however, to apply the term Martinez to these rocks, for Watson (1942) has demonstrated that the rocks of the Martinez formation in its type area on the Pacheco syncline must be divided into two parts, Paleocene and Eocene in age. As Martinez is no longer synonymous with Paleocene, the practice of using this cartographic term in a time-stratigraphic sense might well be abandoned. The rocks in the Santa Monica Mountains are so far removed from the type area of the Martinez formation that eventually they must receive a new formational name or names. Pending detailed stratigraphic work to justify the application of new names to local rock-stratigraphic units the term "Martinez" is used here.

GENERIC NOMENCLATURE

The material collected at locality 2691 includes several specimens of an undescribed gastropod that appears most closely linked to *Serratocerithium* Vignal, a subgenus of *Cerithium* Bruguière. A description of this new species has necessitated a review of the synonymy of *Cerithium* Bruguière and *Clava* Martyn. This synonymic review adduces evidence to raise *Serratocerithium* to generic rank, and, in addition, offers a solution to several problems involved in the synonymy of these genera.

The genus *Clava* was established by Thomas Martyn (1784) as a genus including three—perhaps four—species. These were, in the order in which they were cited, *Clava rugata*, *C. herculea*, *C. maculata*, and *rubus*, perhaps also intended as *Clava*.[1] The first valid designation of a genotype was made by Pilsbry in 1901; he chose Martyn's first species, *Clava rugata* (= *Murex asper* Linnaeus).

Cerithium was established by Bruguière (1789) as a genus without species. This same author described 43 species of *Cerithium*, which, although published in the same volume of the Encyclopédie Méthodique as the proposed new genus, have been given the date 1792 by Sherborn and others. In 1810 Montfort designated *Cerithium virgatum* Montfort as the genotype of *Cerithium*. This is a new name for *Murex vertagus* Linnaeus, which Montfort without justification places in synonymy. *Murex vertagus* was allocated to *Cerithium* by Bruguière. Montfort has thus made a valid designation, and the type of *Cerithium* Bruguière becomes *Cerithium vertagus* (Linnaeus). This synonymic history has been reviewed and approved by G. F. Ferris, chairman of the American Commission of Nomenclature in Entomology and member of the General Council for Zoological Nomenclature.

Unfortunately other species have been widely used as the genotype of *Cerithium*, s.s. For example Cossmann (1889, p. 10), Vignal (1910, pp. 138–140), and Stewart (1927, pp. 355–356) have chosen *Cerithium adansoni* Bruguière as genotype, on the basis of an "indirect tautonomy" with "Le Cerite" of Adanson (1757). The latter is, however, not binomial and pre-Linnaean and thus can not be considered. *Cerithium nodulosum* Bruguière has been used as genotype by a number of authors; apparently the only reason for such a choice—as advanced by Cossmann (1907, pp. 66–67)—is the precedent of other authors. Some writers have adopted *Murex aluco* Linnaeus (*Cerithium aluco* (Linnaeus)) as type, claiming that Lamarck chose this species as genotype in his Prodrome (1799). Lamarck, however, merely mentioned the species as an example of the genus, which does not constitute a valid designation of type.

The true genotype of *Cerithium*, *Cerithium vertagus*, has been recognized by Dall (1907) and Cox (1927, p. 84), but these authors (and subsequently Stewart) introduce a problem by insisting that *Cerithium vertagus* is a *Clava*, and *Cerithium* as a genus must

[1] R. Winckworth in "Notes on nomenclature" (Malac. Soc. London Proc., vol. 18, p. 228, 1929, shows that many of Martyn's names are without Latin generic name and are thus not binomial. If this opinion is followed, *Clava rubus* can not be considered valid, for Martyn supplies no generic name.

thereby fall as a synonym to *Clava*. This problem makes the assignment of new material to either *Cerithium* or *Clava* a complicated task; to facilitate work with such new material the solution reached here is this:

An examination of specimens of *Cerithium vertagus* (Linnaeus) and *Clava asper* (Linnaeus) makes it manifest that at least five distinctive morphological differences exist between these species.

1, *Cerithium vertagus* (Linnaeus) has a heavy parietal callus appressed to the body whorl; *Clava asper* (Linnaeus) has a free callus, not attached to the body whorl. 2, *C. vertagus* has a moderate development of nodes in the early whorls which decreases to a few crenulations on the basal whorl, whereas *C. asper* has an evenly distributed, nearly cancellate ornamentation. 3, A ridgelike disc, lacking on the basal whorl of *C. vertagus*, is present on the basal whorl of *C. asper*. 4, The shell of *C. vertagus* is somewhat barrel-shaped with the penultimate whorl decidedly enlarged, whereas *C. asper* is more angular, the penultimate whorl not so prominent. 5, The anterior canal of *C. asper* is better developed than that of *C. vertagus*. (See pl. 78, figs. 7–12.)

Two distinct biologic groups of species may be established, corresponding to the two genotypes. The following list, as determined by a study of specimens and figures, though not intended to be exhaustive, shows some of the species to be assigned to *Cerithium* Bruguière and to *Clava* Martyn.

Cerithium[2] *cumingii* A. Adams
Cerithium fasciatum Bruguière
Cerithium maculosum (Martyn)
Cerithium martinianum Pfeiffer
Cerithium nobile (Reeve)
Cerithium pharos Hinds
Clava articulata (A. Adams and Reeve)
Clava attenuata (Philippi)
Clava kochii (Philippi)
Clava ravida (Philippi)
Clava recurva (Sowerby)
Clava seminuda (Sowerby)

In addition to these species are a few that have characters of both genotypes, but this evidence need not be considered negative as such links are to be expected in any closely related groups of organisms.

The above evidence is held to be sufficient to separate *Cerithium* Bruguière and *Clava* Martyn as two genera. The family name Cerithiidae need not be affected by this solution.

Likewise, it is possible to show that the genotype of *Serratocerithium* when compared with *Cerithium* and *Clava*, as limited above, differs from them in as many points as they do from each other. It is therefore reasonable to raise *Serratocerithium* to generic rank. Heretofore *Serratocerithium* has been considered a subgenus of *Cerithium*. This group contains a number of species chiefly from the Eocene rocks of the Paris Basin, France, and has as genotype *Serratocerithium serratum* (Bruguière).

The morphological characters that distinguish *Serratocerithium serratum* (Bruguière), as determined by a study of several specimens are:

Shell turrited; basal whorl larger than any other, with base flattened; aperture subquadrate; posterior canal short; anterior canal present; strong row of nodes below suture with typically two, perhaps more, rows of finer nodes, the latter tending to be more marked in the early whorls; growth lines symmetrical. (See pl. 78, figs. 2, 4.)

These characters hold true for all material of the genus *Serratocerithium* in hand as well as for the figures of Cossmann and Pissaro (1904–1906). Specimens of 14 species were examined.

SYSTEMATIC DESCRIPTION

Family CERITHIIDAE

Genus SERRATOCERITHIUM Vignal, 1897

SERRATOCERITHIUM USANIUM Compton, n. sp.

Plate 78, figures 3, 5, 6

Types.—Holotype: Basal whorl and next two whorls of well-preserved adult specimen; Stanford University collection, no. 7756; figures 3 and 6. Paratype: Nine whorls including basal whorl of adult specimen, poorly preserved; Stanford University type collection, no. 7757; figure 5. Type locality: Stanford University locality 2691: Ridge east of Santa Ynez Canyon, 4 miles east of road in canyon, along fire road just west of

[2] All the species of *Cerithium* and *Clava* in this list are included under one genus *Vertagus* by Reeve (1866).

top of ridge, in gray calcareous sandstone layer in buff shales; 400 feet southwest of Hoots' locality 43.

Dimensions.—Holotype: Length (incomplete), 33 mm.; greatest width, 20 mm.; greatest dimension on aperture, 16 mm. Paratype: Length (incomplete), 59 mm.; greatest width, about 20 mm.; apical angle approximately 15°.

Description.—Shell elongate, turrited, incomplete, but with about 12 whorls; body whorl somewhat enlarged, bearing varix to to the left of aperture; whorls of spire flattened to concave; apex not complete but apparently acute; base of body whorl distinctly flattened; outer lip produced and perhaps thickened, inner lip reflected and somewhat appressed to base forming a low callus; aperture large and subquadrate; posterior canal short; anterior canal probably present (indication in paratype); ornamentation of three rows of regular closely spaced nodes, one strong row of nodes forming carina below suture, one row of fine nodes bordering suture, and another one-third way down whorl from suture; finer nodes more conspicuous in early whorls; growth lines fine, closely set, nearly symmetrical, with approximately 25 fine ridges parallel to rows of nodes.

Diagnosis.—As has been pointed out, the genus *Serratocerithium* is typically a turrited gastropod with the basal whorl larger than any other. The base of the body whorl is flattened, the aperture is subquadrate, with an anterior canal and a short posterior one. The whorls bear a strong row of nodes just below the suture with typically two, but perhaps more, rows of finer nodes; the latter are stronger on the early whorls. The growth lines are symmetrical. Because *Serratocerithium usanium*, n. sp., has all of these diagnostic characters it has been assigned to this genus. *S. usanium* differs from the genotype of *Serratocerithium* in that the new species is smaller and less ovoid in shape. The varix on the body whorl and the numerous fine ridges paralleling the nodes on *S. usanium* are not present on *S. serratum*.

Discussion.—Another candidate for the genus *Serratocerithium* is "*Cerithium*" *barquianum* (White) 1897, described as *Nerinaea*. The holotype came from beds in Brazil which White considered to be of Cretaceous age. A specimen in the Stanford collection from the Soldado formation (Paleocene) of Trinidad is here figured. This specimen compares well with the figures and

DISTRIBUTION OF SPECIES FROM THE SANTA MONICA MOUNTAINS

Outside localities[1]	1	2	3	4	5
Locality 2691					
Gastropoda:					
"*Amaurellina*" *martinezensis* (Dickerson).				x	x
"*Fusus*" *flexuosus* Gabb?.			x		x
Heteroterma gabbi Stanton.		x	x	x	
Mesalia martinezensis Gabb.		x		x	x
Neverita sp.			x	x[3]	
Priscofucus caudatus (Gabb).	x		x		x
Retipirula crassilesta (Gabb).	x			x	x
Turritella pachecoensis Stanton.		x	x	x	x
Pelecypoda:					
Brachidontes lawsoni (Nelson).				x	
Callocardia sinedepressa Nelson.[3]				x	
"*Crassatellites*" *branneri* Waring[3]				x	
Cucullaea mathewsonii Gabb.			x	x	x
"*Macrocallista*" *stantoni* Waring.[3]				x	
Nanonavis sp.					
Tellina? undulifera Gabb.		x		x	x
Hoots' localities 43 and 44					
Gastropoda:					
Euspira susannaensis (Nelson).				x	
Sycostoma mucronatum (Gabb).					x
"*Lyria*" *hannibali* Waring				x	
Pelecypoda:					
Glycymeris major (Stanton) of authors.				x	x

[1] Outside localities:

1. Watson: from Stanford University locality 2237A, glauconitic sands at the base of the Martinez formation, in roadcut across from old John Muir homestead, on the southwest limb of the Pacheco syncline near Martinez, Contra Costa County, Calif.
2. Putlitz: in lower 700 feet of his section of the northeast limb of the Pacheco syncline, taken along the Santa Fe Railroad, Contra Costa County, Calif.
3. White: from Stanford University locality 2073, basal sands of the Lodo formation, Panoche quad., sec. 20, T. 15 S., R. 12 E., M.D.M., Fresno County, Calif.
4. Nelson: from localities in the "Martinez marine member" of the Simi Hills, Ventura County, Calif.
5. Dickerson: from the *Trochocyathus zitteli* zone of the Martinez formation at its type area near Martinez, Contra Costa County, Calif.

[2] *Polinices hornii* Gabb of Nelson.

[3] Identified by B. L. Clark, University of California.

text of White. As nearly as can be determined "*Cerithium*" *barquianum* has all the characters of *Serratocerithium* except that the spire of *C. barquianum* is gently concave and has more whorls than *S. serratum*. The presence of numerous fine ridges paralleling the rows of nodes is similar to *S. usanium;* the anterior and posterior canals of *C. barquianum* have not been described. If the allocation of this species to *Serratocerithium* is correct this genus occurs in two widely separated localities in rocks of Paleocene age —records heretofore unpublished.

AGE OF NEW SPECIES

A study of the assemblage collected with *Serratocerithium usanium* at locality 2691 indicates that the sediments in which these specimens were found are of Paleocene age (in the sense that these beds are equivalent to other so-called Paleocene marine sediments of North America, such as the Martinez and Midway formations). Since Watson has shown that not all rocks mapped as "Martinez" in California are necessarily Paleocene in age, a careful selection was made of only those faunas which are definitely from the lower Martinez (Paleocene). The accompanying distribution table was prepared largely by comparisons with actual material from the several localities. The fauna found at Stanford University locality 2691 and Hoots' localities 43 and 44 is listed to the left; the occurrence of the species in Paleocene areas of California is checked on the right.

Dickerson recognized three faunal zones in the Martinez; the middle (*Trochocyathus zitteli*) zone and the upper (*Stolen stantoni*) zone are represented at the type locality of the Martinez formation. Dickerson's columnar section was made on the southwest limb of the Pacheco syncline somewhat southwest of Watson's section. His *Trochocyathus zitteli* zone belongs in the lower Martinez of Watson because: 1, Dickerson indicates his fauna comes from the approximate lower one-third of his column; 2, his localities, when plotted on a map, lie along the strike of the lower Martinez beds; 3, his middle zone fauna is typically associated with glauconitic sands, and similar associations are noted by Watson at the base of her lower Martinez. Dickerson's large faunal list of the *Trochocyathus zitteli* zone may thus be considered typical of the lower Martinez formation and available for so-called Paleocene time correlations.

The evidence offered by the above correlations strongly suggests that the rocks with the fauna at locality 2691 are synchronous with those of the lower Martinez at its type locality. If the lower Martinez sediments of California are Paleocene, then *Serratocerithium usanium* is Paleocene in age.

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EXPLANATION OF PLATE 78

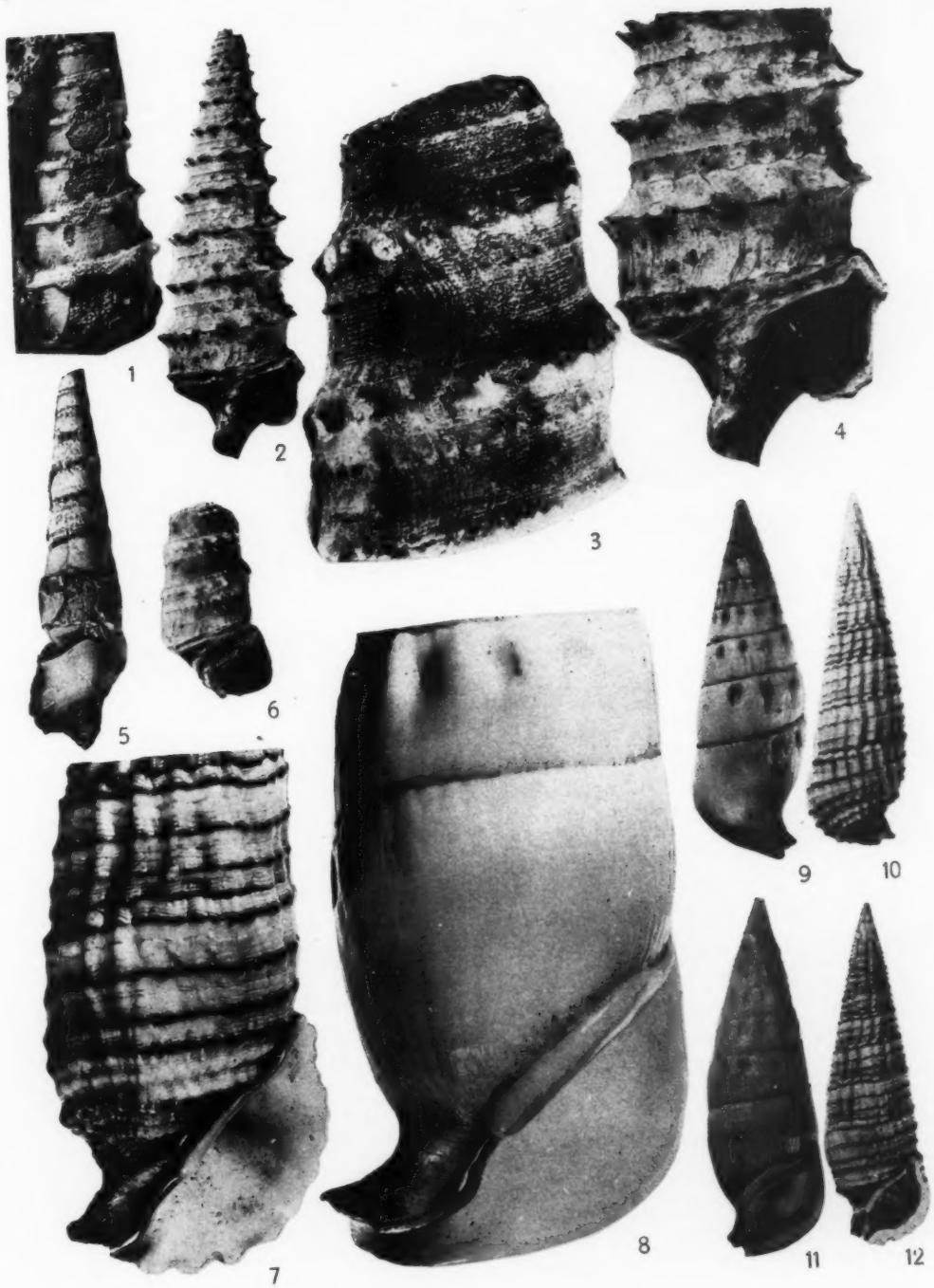
FIG. *1*—"*Cerithium*" *barquianum* (White). Hypotype, in matrix, Stanford type coll. no. 7754, ×2. From the Soldado formation (Paleocene), Marac quarry, Trinidad, British West Indies; collected by H. H. Renz. (p. 467)

2, 4—*Serratocerithium serratum* (Bruguière). Hypotype, Stanford type coll. no. 7755. Fig. *2*, ×1; *4*, same specimen, ×2. From the Lutetian (M. Eocene), Villiers, Saint-Frédéric, France. (p. 466)

3, 5, 6—*Serratocerithium usanium* Compton, n. sp. *6*, Holotype. Stanford type coll. no. 7756, ×1; *3*, same specimen enlarged ×3 to show nodes; *5*, paratype, Stanford type coll. no. 7758, ×1. From Martinez (Paleocene) of southwestern Santa Monica Mountains, Los Angeles County, Calif. (p. 466)

7, 10, 12—*Clava asper* (Linnaeus). Hypotype, Stanford type coll. no. 7758. *10, 12*, Dorsal and apertural views of same specimen, ×1. *7*, Enlarged (×3) view of aperture. Recent, East Indies. (p. 466)

8, 9, 11—*Cerithium vertagus* (Linnaeus). Hypotype, Stanford type coll. no. 7759. *9, 11*, Dorsal and apertural views of same specimen, ×1; *8*, aperture ×3½. Recent from beach at Mambulua, Luzon, Philippine Is.; collected by W. D. Smith. (p. 466)



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THE AUDITORY REGION IN SOME MIOCENE CARNIVORES

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ABSTRACT—The auditory region in two genera of carnivores, *Zodiolestes* Riggs (1942) and *Promartes* Riggs (1942) from the Harrison beds (Miocene) of Wyoming and Nebraska, is described in detail and a comparison made with living forms. *Zodiolestes* is found to have an auditory region in all respects similar to that of the living *Procyon*, while the smaller mustelines on which the genus *Promartes* is based, together with other small mustelines formerly referred to the genus *Oligobunis*, have an ear region comparable with that of the modern *Martes*. The ear of *Pseudocynodictis* and several of the larger mustelines is also discussed, and some conclusions are drawn as to the phylogeny of the Carnivora.

THE CONTRAST in numbers and variety between the Tertiary mustelid fauna of Europe and that of North America has long been recognized. In particular the North American Oligocene and lower Miocene have yielded few specimens. These have been primitive, representative of but few genera, and not clearly differentiated, in the opinion of Scott and Jepsen (1936), from the canids toward which they merge in the Eocene.

Preparation of the Field Museum (since renamed Chicago Museum of Natural History) collections from the Harrison beds, however, uncovered two articulated and virtually complete skeletons of what seemed to be musteline affinities. This led to the investigation, undertaken by Mr. Riggs and continued by the writer, of all the available Miocene mustelines. The American Museum, Amherst College, and Yale University were most kind in lending their types for comparison. Study of this material, which includes three practically complete skeletons and several partial ones, raises the question whether the paucity of North American mustelids may not be due to the habitat of the animals and to unfavorable conditions for preservation. It is clear, at any rate, that by lower Miocene times the mustelids were differentiated into a number of types structurally analogous to and fulfilling the same roles ecologically as the modern genera. In other words, there was an adaptive radiation of mustelines in North America, later in date then the Oligocene radiation in Europe but similar in character.

This was not apparent as long as only lower jaws and fragmentary skulls were known because American Miocene mustelids are practically impossible to distinguish on the basis of dentition alone. It was this lack of variation from a generalized dental pattern which has caused the genus *Oligobunis* to be referred to three different families representing groups of superfamily rank at least.

Cope (1884) described a pair of lower jaws and the anterior part of a skull from the John Day formation as a new canid genus, *Oligobunis crassivultus*. Matthew (1907) re-examined the type and, on the basis of the general mustelidlike proportions and the absence of the precarnassial construction of the muzzle characteristic of the Canidae, placed *O. crassivultus* in the Mustelidae. At the same time he proposed a new species, *O. lepidus*, for several of the smaller referred specimens. Thorpe (1921) added *O. darbyi* from the Monroe Creek beds. The skull of this specimen was sufficiently complete for basicranial characters to be added to the definition of the genus. The late Professor Loomis (1932), collecting in the lower Rosebud beds of South Dakota, found an articulated skeleton and another small skull which he referred to *Oligobunis* and at the same time expressed the belief that *Oligobunis* was a viverrine.

Prior to Loomis's description of *O. gemmarosae* the larger Field Museum specimen had been referred to *Oligobunis* on the basis of the dentition, which is identical. Loomis's description of the skeleton of *O. gemmarosae*, however, clearly did not fit the skeleton of this specimen. Moreover, further work on the Corkscrew material in the Field Museum disclosed a second skeleton of musteline

affinities, and this specimen was a short-legged, large-headed individual quite unlike either of the other two.

It was in an endeavor to ascertain the relationships of these specimens that a dissection of the auditory region was undertaken, that region having been made the basis of the classification of the carnivora by Flower's (1869) classic paper. The outcome of the study as stated by Riggs (1942) has been the separation of the smaller mustelines from the genus *Oligobunis* and the erection of two new genera, *Promartes* and *Zodiolestes*. The description of the auditory region is presented in this paper. The postcranial skeleton will be described in a forthcoming publication of the Chicago Museum of Natural History. Only such mention is made of it here as is necessary for the elucidation of relationships.

The writer wishes to thank the Chicago Museum of Natural History for the opportunity of studying and describing these specimens in the Museum collections, and in particular Mr. Riggs, under whose direction the work was initiated, and Mr. Patterson, the present Curator of the Department of Paleontology, for much help in the way of criticism and suggestion. Thanks are also due to Dr. E. C. Olson, under whose supervision the manuscript was revised into its present form, and to Professor A. S. Romer, to whom the writer is much indebted not only for help with this work but for the teaching that first inspired an interest in paleontology.

THE AUDITORY REGION OF PROMARTES

The auditory region of *Promartes* is strikingly similar to that of the recent marten. In fact, in all essential structures the two genera are identical. This is not apparent from a superficial examination because certain features in the modern mustelids, the flattening of the bulla, the septae (which are visible externally as lines radiating from the juncture of the meatus and the bulla), and an external tubular meatus mask the similarity of the internal structure.

The following description is based largely on the holotypes of *P. olcotti* and *P. vantasselensis*, the other specimens being like them in structure but too incomplete to furnish any additional data.

In all known specimens of this genus, the bullae are broken. In *P. olcotti* (Chicago Mus. P. 15178) the area around the porus acusticus externus and the rostral portion are intact, but the left bulla is displaced forward and the right restored from sections. (Fig. 1.) In the holotype of *P. vantasselensis* (Amherst 2092) only the part of the lateral

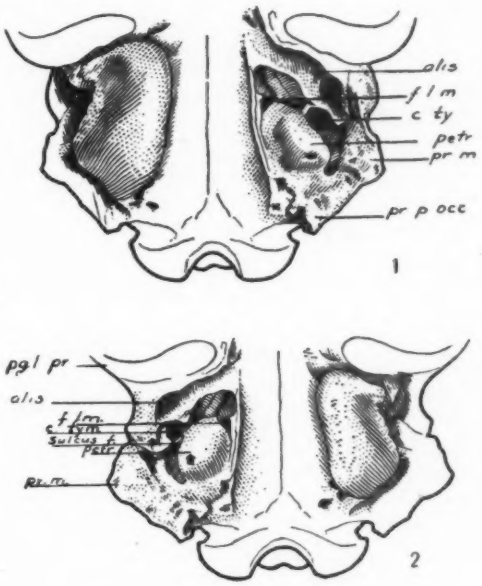

FIG. 1—*Promartes olcotti* Riggs. Left auditory region dissected to show structures of middle ear. *flm*, Foramen lacerum medium; *cty*, cavum tympani; *petr*, petrosal; *prm*, processus mastoideus; *prpocc*, processus paroccipitalis.

FIG. 2—*Promartes vantasselensis* Riggs. Right auditory region dissected to show structures of the middle ear. *pglpr*, Postglenoid process; *alis*, alisphenoid; *ctym*, cavum tympani; *sulcus f*, groove for the facial nerve; *petr*, petrosal; *prm*, processus mastoideus.

wall immediately surrounding the porus adusticus externus, the rostral wall and the caudal rim are present. (Fig. 2.) In that of *P. darbyi* (Yale University 10272) the rostral wall, and the region of the porus acusticus externus are preserved. In a referred specimen of *P. lepidus* (Chicago Mus. P. 14055) the greater part of the basicranium has been weathered away. Enough pieces of the surrounding surface of the left bulla remain to allow it to be patched together, but

the rest of the basicranium has been restored in plaster. Therefore, nothing but the shape and size of the bulla can be certainly known. From a study of all the specimens, however, all the more important details of both the internal and external structures can be accurately determined.

The bullae in *Promartes* are close together and set obliquely to the median line of the skull. They are much expanded medially and ventrally, the medial walls being almost vertical. As far as can be determined from the specimens studied, none of which have the bulla intact, the tympanic is the only element taking part in the formation of the bulla. It is true that the bullae in this genus all separate around the porus acusticus externus leaving the meatus, the crista tympanica and a semicircular portion of the lateral walls intact, a condition that might be interpreted as indicating the presence of an entotympanic. On the other hand, however, there is no indication of a septum bullae, each bulla being composed apparently of a single, undivided chamber.

Professor Loomis described the holotype of *P. vantasselensis* as having a partial septum in the bulla, dividing it into anterior and posterior chambers. After careful cleaning of the holotype specimen, however, it was found that such a structure was not present, and that the bulla of this specimen is undivided as in *P. fossor*, *P. darbyi*, and *P. gemmarosae*.

The hypotympanic sinus is very deep because of the ventral expansion of the bulla and, in addition, extends ventrolaterally along the anterior and posterior walls of the bony tubular meatus, which projects freely into the cavity of the ear.[1] The extent and cylindrical character of the meatus are not visible externally because of this extension of the sinus. In *Martes* this same extension of the sinus is present, but it is narrower. Also, the external auditory meatus is more completely ossified, forming a long projecting tube.

The anterior half of the roof of the meatus is formed of the squamosal, the posterior of the periotic. There is no dorsal extension of the tympanic as in *Martes*, where the tympanic forms almost a complete tube.

[1] Van der Klaauw (1931) described this condition in *O. darbyi*.

The porus acusticus externus is oval and inclined at an angle of 70° to the horizontal. The posterior wall of the porus is fused with the mastoid. A suture is clearly discernible between the tympanic and the processus post-glenoideus. The crista tympanica is thick and stands out prominently from the lateral wall of the bulla.

The epitympanic recess lies directly under the porus acusticus externus, and both the tympanic cavity proper and the fossa for the tensor tympani muscle are relatively large.

The anterior portion of the auditory region is much broken in *P. fossor* and *P. vantasselensis*. The right side, which is intact, is displaced forward, all of which somewhat obscures the relationships in this region. It is clear, however, that the inflected margin of the bulla forms a shelf, which extends from the anterior dorsal margin of the crista tympanica to the stylomastoid foramen leaving only the summit of the promontorium exposed.

The large oval fenestra cochleae faces posteriorly. The somewhat smaller fenestra vestibuli faces laterally and forward.

The apertura canalis facialis opens dorsally to the fenestra vestibuli into a short sulcus facialis set into the periotic. The sulcus runs posteriorly and somewhat outward leading into a groove, which passes downward along the medial surface of the mastoid process to the foramen stylomastoideum definitivum. A shallow fossa occupies the position of the stylomastoideum primitivum. It is covered by the inflected margin of the bulla, however, and the facial nerve could not have traversed it but reached the exterior of the skull by means of a bony canal formed by the mastoid dorsally, the tympanic ventrally. This is the condition in the specimens of *Martes* and *Taxidea* examined by the writer. It is the general rule for all Mustelidae and most modern carnivora according to Matthew, Pocock, and Van der Klaauw (Van der Klaauw, 1931). In the Procyonidae and many creodonts, in which, however, the bulla is not preserved, many of the Insectivora, and Edentata according to Van der Klaauw, the foetal condition is retained and the facial nerve leaves the tympanic cavity through the foramen stylomastoideum primitivum,

there being no bony third part to the facial canal. Removal of the bulla, however, also removes this part of the canal, if it is present, so that in many cases where the bullae are lost or badly crushed it is impossible to say whether a foramen stylomastoideum definitivum was present or not. The tympanohyal was evidently not included in the bulla in *Promartes*, since there is a concavity on the outside of the bulla similar in appearance and position to that which lodges the tympanohyal in recent specimens, and the presumption is that such was the position of that element here.

The broken condition of the anterior and medial portions of the bulla in *P. fossor* precludes any statement as to the course of the carotid artery in that species. In *P. vantasselensis*, however, it appears to have the same course as in *Martes*, *Taxidea* and, according to Van der Klaauw, most modern mustelids where the foramen caroticus posterius, situated along the anterior third of the medial margin of the bulla, opens into a short deep groove or canal in the tympanic. The groove follows a curved course forward and in front of the foramen lacerum medium comes to lie between the basisphenoid medially and the tympanic laterally.

Just lateral to the carotid canal is the orifice of the Eustachian tube, the two being separated by the lateral wall of the canal. There seems to be no styliform process in *P. vantasselensis* or *P. darbyi;* in *P. fossor* the anteromedial portion of the bulla is prolonged into a sharp point.

Anteriorly the tympanic is in contact with the alisphenoid, which has a very short extension under the bulla, apparently forming the roof of the Eustachian tube. Anteriorly and laterally the bulla presses closely against the postglenoid process, which is thus not very prominent. It appears to be absent altogether in *Martes*. Laterally, the posterior leg of the tympanic is more or less fused with the mastoid, although the contact is traceable. The mastoid process is small, and the mastoid itself has but little exposure laterally. The paroccipital process is pressed closely to the back of the bulla in *P. vantasselensis*, but in *P. fossor* the process appears to project slightly, extending backward and downward. However, this process is very variable in modern mustelids. In *Martes* it is large but in *Mustela* much reduced (Van der Klaauw, 1931). In *Taxidea* the process is broad, blunt, and projects downward. Such differences may occur in the same genus, *Galictis barbara* having a well-developed paroccipital process, while in *Galictis intermedia* and *G. vittata* it is reduced. (Van der Klaauw, 1931.)

Relationships.—Structures of the middle ear, such as the presence or absence of a hypotympanic sinus, the position of the facial canal, the course of the carotid artery and the conformation of the crista tympanic have become established as criteria of relationships because of their nonadaptive character, as generally supposed. On this basis there is no doubt that these smaller Miocene mustelines are closely related to the modern *Martes*. They are not, however, separable from *Oligobunis* on the basis of dentition, and the auditory region of the type, *Oligobunis crassivultus*, is unknown. Until it is known the separation must remain tentative. The erection of the genus *Promartes*, seemed justifiable because, as will presently be seen, the auditory region provides a very clear basis for the distinction of other genera that have been or might be referred to *Oligobunis* on dentition alone. The smaller mustelines form a natural group, from which *Oligobunis* and the larger types are excluded. It is not within the scope of this paper to discuss the relationships of the smaller species with each other. (Much work remains to be done on speciation in fossils, and when the principles that govern the development and radiation of early groups are better known it may well turn out that entire assemblages such as the smaller Miocene mustelines referable to *Promartes* formed one highly variable species.)

THE AUDITORY REGION OF ZODIOLESTES

The specimen on which the following description is based is the beautifully preserved "corkscrew carnivore," the occurrence of which in the daimonelix spirals was reported by Mr. Riggs to the Paleontological Society at the Baltimore meeting in 1908. The skull and skeleton are both so perfect that details of the anatomy can be determined with as much precision as from a freshly prepared specimen.

The animal, which was found curled up as

if asleep in one of the daimonelix spirals, must have been of about the size and proportions of *Cryptoprocta ferox* and perhaps similar in habits also. The resemblance, however, is purely superficial since nothing in the skull or skeleton indicates viverrine or feline characters. On the contrary, the skull is very similar in general aspect to that of *Procyon lotor*, the main difference being the shortening of the basicranium in the modern animal. The dentition is mustelid and similar to that of *Oligobunis crassivultus*. The tooth row in the type of *Oligobunis*, however, is very crowded due to the shortening of the muzzle, one of the features that makes the resemblance of *Oligobunis* to *Gulo* so striking. There is nothing of this sort at all in *Zodiolestes*. The inferior margin of the lower jaw, however, shows a further mustelid character in that it lacks the curve characteristic of canids and procyonids. To complete this extraordinary combination of characters taken from every carnivore family, the ear region (fig. 3) is, in all essential respects, identical with that of *Procyon*.

The bulla is an oval, evenly rounded capsule formed by the tympanic only, and consisting of a single undivided chamber. The hypotympanic sinus is small and entirely devoid of internal rafters or septa. It has no extension into exoccipital. The divisions of the bulla cannot be distinguished externally. There is no bony meatus; the porus acusticus externus is a circular opening interrupted ventrally by a narrow slit, a vestige of the original tympanic ring. The anterior and ventral walls of the porus are roughened for the attachment of a cartilaginous, tubular meatus. The external meatus is a curved gutter closed dorsally by the superficies meatus of the squamosal. In this roof immediately external to the porus margin there is a large fossa, which is separated from the epitympanic recess by a rim of bone forming the lateral wall of the recess. The function of the fossa is apparently unknown. It was not found in any of the mustelids, canids, or felids examined, but was observed as a feature of the raccoons including the little panda.

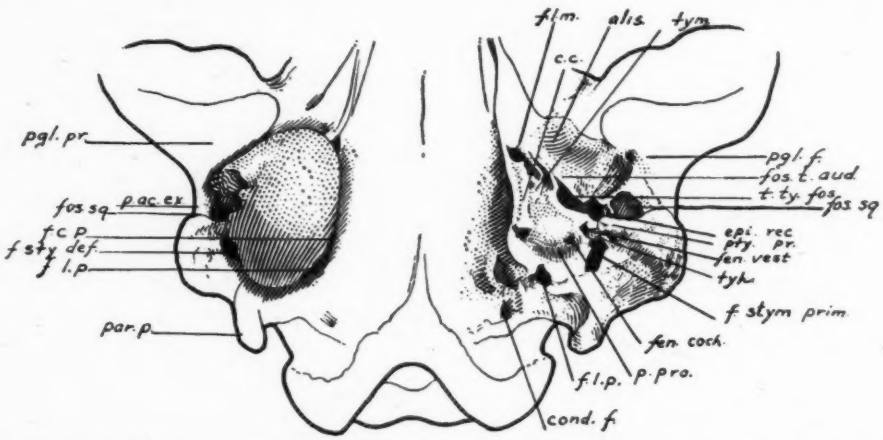

FIG. 3—*Zodiolestes daimonelixensis* Riggs. Left auditory region dissected to show structures of the middle ear. *flm*, Foramen lacerum medium; *cc*, carotid canal; *alis*, alisphenoid; *tym*, tympanic; *pglf*, postglenoid foramen; *fostaud*, fossa tuba auditiva; *ttyfos*, fossor for the tensor tympani; *fossq*, fossa of the squamosal; *epirec*, recessus epitympanicus; *ptypr*, processus pterygoideus; *fenvest*, fenestra vestibuli; *tyh*, tympahohyal; *fstymprin*, foramen, stylomastoideus primitivum; *fencoch*, fenestra cochleae; *ppro*, promontorius prooticus; *fld*, foramen lacerum posterium; *condf*, condylar foramen; *parp*, paroccipital process; *fstyldef*, foramen stylomastoideum definitivum; *fcp*, posterior carotid foramen; *pacex*, porus acusticus externus.

The crista tympani is a thin, horseshoe-shaped rim of bone extending ventrally into the ear at an agle of about 30° to the horizontal.

The epitympanic recess is quite small and lies almost directly under the porus.

The true tympanic cavity is small and well separated from the epitympanic recess by a thin shelf of bone. From the tympanic cavity a groove for the Eustachian tube

runs forward in the alisphenoid. More anteriorly the groove becomes a fissure, the sides of which are formed by the inflected margins of anterolateral and anteromedial walls of the bulla and the roof by the alisphenoid. This fissure leads into an opening at the anteromedial angle of the bulla, which is just lateral to the opening for the foramen lacerum medium and separated from it by the short styliform process. The reflected margins of the bulla extend but little over the periotic and the rounded promontorium is extensively exposed. From the anterior margin of the eminence a thin lamella of bone extends forward between the alisphenoid laterally and the tympanic medially.

The fenestra cochleae is a small opening facing more posteriorly than laterally. The fenestra vestibuli is slightly larger and faces laterally. The fossa for the tensor tympani muscle is broad and deep and lies just medial and anterior to the epitympanic recess.

The aperatura tympanica canalis facialis opens just above the fenestra vestibuli. Above, and slightly laterally to the fenestra, is a small foramen leading into a short canal, which enters the posterior wall of the tympanic cavity and opens just beneath the small process that bounds the foramen stylomastoideum primitivum anteriorly. This process is pierced by a minute foramen for the chorda tympani.

A wedge-shaped groove on the mastoid marks the further progress of the facial nerve through what must have been a ligamentous canal (as in the raccoon) passing from the foramen stylomastoideum primitivum to the foramen stylomastoideum definitivum. This condition may be a primitive one for the carnivora, since a foramen stylomastoideum primitivum occurs in creodonts described by Matthew (1909) and more recently by Denison (1938) who also describes a "stylomastoid canal" for *Patriofelis*. Apparently the more specialized creodonts developed a bony canal for the facial nerve in much the same manner as the true carnivores.

Considerable interest also attaches to the small process mentioned above as forming the anterior boundary of the foramen stylomastoideum primitivum. In creodonts this process was originally thought by Matthew (1909) to be a spur of the posttympanic process of the squamosal. This does not seem to be the case in *Zodiolestes*, since the suture that separates the process in question from the squamosal is very clear. Van der Klaauw (1931) suggested that this spur might represent the tympanohyal, which usually bounds the stylomastoid foramen anteriorly. Denison (1938) is inclined to this view. Such an interpretation seems to be quite in accordance with conditions in *Zodiolestes*, where, since there is no separate pit or groove for the tympanohyal, the hyoid in all probability terminated, as in *Procyon*, in a cartilage, which lay along the dorsal margin of the foramen stylomastoideum primitivum. (There is a roughened area that suggests such an attachment.) In that case, the tympanohyal, ossifying separately, would become attached to the petrosal, and extending from the mastoid process to the periotic, bound the foramen stylomastoideum primitivum anteriorly.

The carotid canal is a rather large tube, formed by the tympanic. It runs along the medial wall of the bulla from a point slightly anterior to the foramen lacerum posterium to a point just ventral to the foramen lacerum medium. The latter foramen is small and penetrates the alisphenoid at the posterior margin of a deep oval fossa, lying immediately medial and slightly posterior to the opening for the Eustachian tube. The foramen and the fossa are entirely covered by the bulla. From the position of the opening it is evident that the internal carotid artery must have doubled backward and upward in order to pass into the cranial cavity. This is also the condition described by Flower (1869) as occurring in the Ursidae.

Medially, the bulla is in contact with the basisphenoid and the basioccipital, these two bones curving downward slightly to embrace part of the medial wall. The contact with the basioccipital is slight because of the large size of the foramen lacerum posterium. Posteriorly the bulla falls just short of contact with the base of the slender, backwardly directed paroccipital process. The suture between the paroccipital and the mastoid runs obliquely from the lateral edge of the promontorium. The mastoid process, which extends forward and laterally as a broad, rough process, thus forms the entire lateral margin of the foramen stylomastoideum definitivum.

Anteriorly, the bulla presses closely to the base of the postglenoid process, almost covering the small postglenoid foramen. The attachment of the bulla to all these surrounding elements with the exception of the basisphenoid is slight and the bulla easily broken away.

The type of auditory region just described is very different from that of *Promartes*. The most significant differences are:

Zodiolestes

Carotid canal formed by the tympanic along the medial wall of the bulla.

A foramen stylomastoideum primitivum is present, and the facial canal must have been ligamentous in its external third.

Tympanohyal lodged in a groove on the surface of the bulla.

Promartes

Carotid canal lies in a groove between the basisphenoid and tympanic bones in the roof of the bulla.

A foramen stylomastoideum definitivum and a bony third part to the facial canal are present.

Tympanohyal ossified and enclosed in the bulla.

Relationships.—There is no doubt whatever that *Zodiolestes* should be classified with the Procyonidae on the basis of the ear region. However, there is nothing in the postcranial skeleton to indicate any of the adaptive characters of *Procyon*. The teeth also are without the specialization typical of the omnivorous habits of the raccoon. It is interesting also that the foramen transverum of the atlas is connected with the atlantal foramen by an open groove. According to Denison (1938) this is a fundamental character indicative of family or superfamily relationships. However, he goes on to say that this connection is made in the Pseudocreodi and the Mesonychidae by a shallow groove, in the Canidae and Felidae, Procyonidae, and *Miacis* by a deep groove, while in the Ursidae, Mustelidae, Viverridae, Hyenidae, and *Oodectes* (Miacidae) it becomes a foramen. The character appears to have been variable in the Miacidae but fixed in one direction or the other in all later forms. This could be considered evidence of Procyonid affinities for *Zodiolestes*, but of course one character of that sort can not be relied upon as definitive.

THE EAR IN SOME LARGER MUSTELINES

In addition to the specimens described, the Chicago Museum of Natural History has an undescribed specimen, a much larger mustelid probably referable to *Aelurocyon*. Only the basis cranii of the skull is preserved. This, however, is extremely interesting because the tympanic bulla, which has radiating septae strongly resembling those of *Gulo*, covers only the anterior portion of the auditory region. Teilhard de Chardin (1915) described such a bulla in *Paleoprionodon*, and this same condition was reported by Van der Klaauw for *Daphoenus*. *Pliocyon*, on the other hand, according to Teilhard de Chardin, has an anterior bulla, and, in addition, the remnants of a bony entotympanic surrounding the tympanomastoid canal. This may indicate a completely ossified entotympanic, with only this part preserved in the fossil, or a cartilaginous entotympanic with only the beginning of ossification. In any case, the presence of a bulla with an anterior tympanic chamber in these genera is strong evidence, as Scott has pointed out (1889), for the early appearance of this character. It also brings the Viverridae, which have an anterior-posterior-chambered bulla easily derivable from these early types, closer to the cynoid group and emphasizes the isolation of the modern Felidae, where the bulla with its lateral and medial chambers ossifies in quite a different way.

Whether the bulla is divided or not might not then be as much a criterion of relationship as the manner in which it is divided. A viverrine type of anterior-posterior chambers could be derived from that of *Paleoprionodon* by ossification of the cartilaginous entotympanic; an undivided bulla such as that of *Gulo* from a "demibulla" of the Aelurocyon type by some such means as an increase in the rate of ossification from the tympanic center so that the posterior cartilage would be absorbed in the growing sheet of bone. A feline type of bulla, however, in which according to Flower (1869) the entotympanic at birth is represented by a strip of hyaline cartilage lying between the tympanic and the basioccipital, and which ossifies from a center near the anterior opening of the Eustachian tube, could not be derived from either without a genetic change great

enough to alter the entire plan of ossification.

AUDITORY REGION OF PSEUDOCYNODICTIS

Pseudocynodictis from the John Day and White River has been generally recognized as a true although primitive canid in spite of the civetlike appearance of the body generally. It has also been considered as a possible ancestor not only of the dogs but of the raccoons through *Phlaocyon*. A description of the auditory region of *Pseudocynodictis* is therefore included here for purposes of comparison.

The bulla is very like that of *Zodiolestes* in general shape but is larger proportionately, more inflated, and very thick, closely resembling modern dogs in these features. The medial wall of the bulla is very steep, more so than in *Canis*, and a cylindrical bony meatus is lacking. The membranous external auditory meatus must have rested directly on the superficies meatus of the squamosal. The porus acusticus externus is an oval opening inclined forward with the largest diameter dorsoventral.

The crista tympanica is thin and sharp, lying close to the lateral wall of the bulla. It has much the same extent and relations as that of *Canis*. The large shallow epitympanic recess is almost entirely medial to the porus acusticus externus. It is separated from the tympanic cavity by the outer wall of the sulcus facialis. The tympanic cavity is deep and lies medial and forward of the recessus. The fossa for the tensor tympani muscle lies entirely forward of the tympanic cavity and is large and shallow. The tympanic process of the alisphenoid extends almost to the anterior margin of the promontorium. There is only a slight grooving to indicate the position of the tuba auditiva. It was evidently enclosed in cartilage not bone. There seems to be no division of the large opening at the anteromedial corner of the bulla, and if the Eustachian tube (tuba auditiva) and the entrance to the foramen lacerum medium were separated by a partition this must also have been of cartilage. The foramen lacerum medium is bounded by the basisphenoid medially, the periotic posteriorly, and the alisphenoid anteriorly.

The promontorium is prominent and pear-shaped with a small fenestra cochlea looking posterolaterally and a large round fenestra vestibuli facing outward and forward.

The apertura tympanica canalis facialis is minute and opens into a definite sulcus facialis somewhat anteriorly to the fenestra vestibuli.

The bulla appears to be ankylosed to all of the elements surrounding it—the basisphenoid medially, the mastoid and glenoid process laterally, and the base of the paroccipital posteriorly. There is little overlap, however, of the inbent dorsal margin of the bulla on the promontorium, the inbent portion being largely anteromedial, where its dorsal surface forms the roof of the canal between it and the periotic, through which the carotid artery reaches the foramen lacerum medium.

The mastoid process is moderately developed, and its medial point is ankylosed to the posterior leg of the tympanic. The posterolateral corner of the bulla is firmly attached to the base of the paroccipital process, which process is blunt and straight, pointing directly backward with only a slight downward inclination.

The foramen stylomastoideum definitivum is large. There does not seem to be any groove or depression in the bulla for the tympanohyal.

Relationships.—Pseudocynodictis is most certainly a dog if the features of the auditory region are used as a criterion. It is remarkable, moreover, to find in this early form all the essential canid characteristics of this region so clearly displayed. *Pseudocynodictis* has also been considered a possible ancestor of the raccoons. This seems improbable since, as has been shown, the procyonid type of ear must have developed at least as early, and there is no evidence of its derivation from that of *Pseudocynodictis*. The direct relationship of *Pseudocynodictis* to *Daphoenus* might possibly also be questioned since, as was mentioned in the discussion of the ear in the larger mustelines, *Daphoenus* has a two-chambered bulla and therefore is much closer, as to auditory region at least, to the European *Paleoprionodon* than the American *Pseudocynodictis*.

SUMMARY AND CONCLUSIONS

Judging from the available specimens, the Mustelidae of lower Miocene times were a

genetically closely related assemblage composed of two size groups—the one, large animals the size of a bear or jaguar, the other including smaller types which vary from the size of a marten to that of a wolverene. *Oligobunis* and *Promartes* belong to the group of smaller animals.

The dentition is similar in all, the principal variation being the presence or absence or relative development of the first premolars. The basicranial region of *Oligobunis crassivultus* is unknown. The likeness to *Gulo* of the parts comparable in the two is very striking, and if this likeness holds good for the rest of the skull, the basicranial and auditory regions should show a corresponding similarity of structure. The large Chicago Museum specimen similar to *Aelurocyon* shows an auditory region very like that of *Gulo*, with a demibulla as has been noted.

Of the smaller animals referred to *Promartes* the basicranial and auditory regions exhibit close similarity to each other and to *Martes actuosa*. The structure and position of the facial canal, the course of the internal carotid artery, the extension of the hypotympanic sinus ventrally along the sides of the tubular meatus which extends into the cavity of the ear, the conformation of the crista tympanica,—all are typically mustelid in character, being the basic structures that are found in all genera of the family and are overlain by later specializations such as the degree of inflation or flattening of the bulla, development of septa, extension of hypotympanic sinus into the ex-occiptal, and coossification of the tympanic with surrounding elements.

Zodiolestes has none of these characters. The carotid canal runs along the medial wall of the bulla and is a stout tube formed by the tympanic; the external auditory meatus does not project into the cavity of the ear; there is no extention of the hypotympanic sinus along the sides of the meatus; a foramen stylomastoideum primitivum is present and there is no bony third part to the Fallopian canal; the tympanohyal is ossified (if the spur bounding the foramen stylomastoideum primitivum anteriorly is to be regarded as the tympanohyal) and lies inside the bulla. These characters are also found in *Procyon*. The question is whether this type of bulla is primitive for the whole of the carnivora, the Procyonidae having retained such primitive features or whether this sort of structure is characteristic only of the Procyonidae. An equally good argument may be presented for either side because, on the one hand, *Zodiolestes* does not have any of the dental specializations characteristic of the Procyonidae and does have the straight inferior margin to the lower jaw characteristic of the Mustelidae, and on the other, mustelids with typical features of the ear and basicranium, the *Promartes* group existed together with, and probably as early as, *Zodiolestes*. If *Zodiolestes* is considered a mustelid, then a procyonid type of auditory region must be primitive for the Mustelidae. It would seem more plausible, however, to consider *Zodiolestes* an early procyonid.

Pseudocynodictis has also been suggested as a possible ancestor of the raccoons as well as the dogs, on the basis of dentition. Scott expressed doubt as to the validity of this relationship. The studies of the ear confirm this viewpoint. The position of the internal carotid artery in *Pseudocynodictis*, the ankylosis of the bulla to the surrounding elements, the conformation of the crista tympani (very similar to that of *Canis*), the absence of a foramen stylomastoideum primitivum, all are typically canid. It is impossible for this type of ear to be ancestral to the procyonid type because all of the essential features are specializations, many of which, such as the thickening of the bulla, its ankylosis to the surrounding elements, and the development of a bony third part to the Fallopian canal are found in living carnivore families.

In fact, if only the characters of the basicranium are taken into consideration it would seem that the main carnivore families were already established by Miocene times. In adaptive characters, however, these early forms are neither typical of their respective groups nor sufficiently generalized to be directly ancestral. *Pseudocynodictis*, for example, is not doglike in skeletal characters, presenting rather, according to Scott, civetlike features. These are usually explained as primitive characters lost by the later dogs and retained by the civets. However, not only must an adaptive transformation of the skeleton take place, but also a change in such nonadaptive characters as the baculum (which in *Pseudocynodictis* resembles that of a raccoon) while other adaptive char-

acters such as those found in the dentition, and nonadaptive characters of the basicranium and auditory region remain stationary.

Zodiolestes, too, while having a procyonid basicranium has no suggestion of the arboreal specializations of *Procyon*, or *Nasua*, but was even more digitigrade than *Bassariscus*, usually considered the most primitive modern representative of the family. The plantigrade feet of *Procyon* are generally interpreted as a secondary development. However, the forefeet of *Procyon* closely resemble those of the lower primates in structure and function and if a secondary development, a semidigitigrade forepaw with a reduced first digit must be transformed into the long-fingered prehensile "hand" which enables this animal in captivity to be as mischievous as a monkey.

There are at least two adaptive types in *Promartes*, which differ so greatly that it is doubtful if, from the standpoint of morphology, they should be included in the same genus. The one, *P. olcotti*, probably resembled the marten in structure and habits, the other with rabbitlike long hind legs finds its nearest modern counterpart in the *Enhydra*, a small aquatic mustelid inhabiting the North Pacific islands.

Nor is it only the adaptive characters that present difficulty in tracing phylogenies. There are anomalies in the basicranial and auditory characters as well. For example, *Daphoenus*, which is certainly a primitive canid, has a demibulla, with presumably a cartilaginous entotympanic in life. We have seen in this paper that at least one of the larger mustelines has such a demibulla, and Van der Klaauw has described a similar structure for *Pliocyon*. The presence of this feature in *Daphoenus* has usually been explained in the same way as the feline aspect of the skeleton, i.e. that it is primitive and retained by some groups, lost in others. There is very little, however, except the need for such a theory to recommend that explanation. The majority of European carnivores described by Teilhard de Chardin have an undivided bulla if any at all, the demibulla occurring only in some of the Stenoplesictoidea, all of which have reduced dentition, whereas *Daphoenus* retains a third upper molar.

This character is especially significant because the division of the Carnivora into Aeluroidea and Arctoidea depends largely on the presence or absence of an ento-tympanic. Yet it appears from the fossil evidence that certain "arctoid" groups retained such a character as late as Pliocene times.

The truth of the matter seems to be that the history of the Carnivora as it is gradually being worked out from the now abundant fossil remains is no simple splitting into two or three continuously diverging groups, which in turn branched out into the ancestors of the modern families. In fact, the search for common ancestors in that sense would seem to be futile. An ancestral group with a certain range in variation, a field on which evolution as directed by natural selection could operate, probably represents a truer picture. To work out all of the forces controlling such an evolution and the mode by which the various families of modern Carnivora developed is far beyond the scope of this paper. The writer hopes, however, to consider all of these problems as completely as possible in a later publication.

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PALEONTOLOGICAL NOTES

CORRECTIONS FOR A "CHECK LIST OF THE FOSSIL REPTILES OF NEW JERSEY"

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This note will call attention to certain corrections to Rapp's (1944) most useful list of the fossil reptiles of New Jersey.

On page 285, Mr. Rapp refers *Hypsognathus fenneri* to the family Pantylidae of the order Cotylosauria. That *Hypsognathus fenneri* is a cotylosaurian was the conclusion reached by Gilmore in his original description, based upon the single type specimen. It is difficult to understand, however, why this genus and species should be referred to the family Pantylidae, because Gilmore made a particular point of the fact that relationships beyond the ordinal ones could not be inferred upon the basis of material at hand. Indeed, Gilmore was none too sure of his assignment of *Hypsognathus* to the Cotylosauria; the identification was reached by him more as a provisional reference than as a definite assignment. Therefore, it would seem best, upon the basis of published material, to refer *Hypsognathus fenneri* to the Cotylosauria incertae sedis, as was done by Hay in 1930.

A beautiful Triassic cotylosaurian skeleton from a quarry near the type locality of *Hypsognathus fenneri* and probably that species indicates an animal most definitely of procolophonid relationships. Therefore, *Hypsognathus* is probably a member of the Procolophonidae, not of the Pantylidae. This is certainly in line with our knowledge of the cotylosaurs, of which the Procolophonidae, hitherto known from Europe and Africa, is the single family surviving into Triassic times. The Pantylidae (the relationships of which are debatable) have hitherto been known only from the lower Permian.

In listing the various fossil crocodilians found in New Jersey, Rapp includes all of the several known genera in the family Pholidosauridae. It is evident, however, that, except for species belonging to the genus *Hyposaurus*, the fossil crocodilians of New Jersey are true eusuchians belonging to the families Crocodilidae and Alligatoridae.

Another correction for the check list concerns *Clepsysaurus pennsylvanicus*, which is included by Rapp on page 287 in the family Dinodontidae of the "order" Dinosauria. In the first place it might be pointed out that virtually all modern authorities are agreed that the term "Dinosauria" is a rather broad term including two well-defined orders, the Saurischia and the Ornithischia. Secondly, although *Clepsysaurus pennsylvanicus* was included in the family Anchisauridae of the order Saurischia by Hay in 1930, upon the basis of an opinion reached by Cope in 1869, all other authorities have, for good reasons, classified this animal among the phytosaurs. Reference should be made to a recent contribution by Colbert and Chaffee (1941) in which the type of *Clepsysaurus pennsylvanicus* is carefully restudied and the genus revised. Its position as an undoubted phytosaur is confirmed in this paper.

Finally, almost all vertebrate paleontologists will disagree with Rapp's procedure of placing many extinct reptiles generally regarded as of Mesozoic age in the Eocene. This applies to almost all of the turtles included in his list, to the plesiosaurs, to most of the crocodilians, to the dinosaurs and to the mosasaurs.

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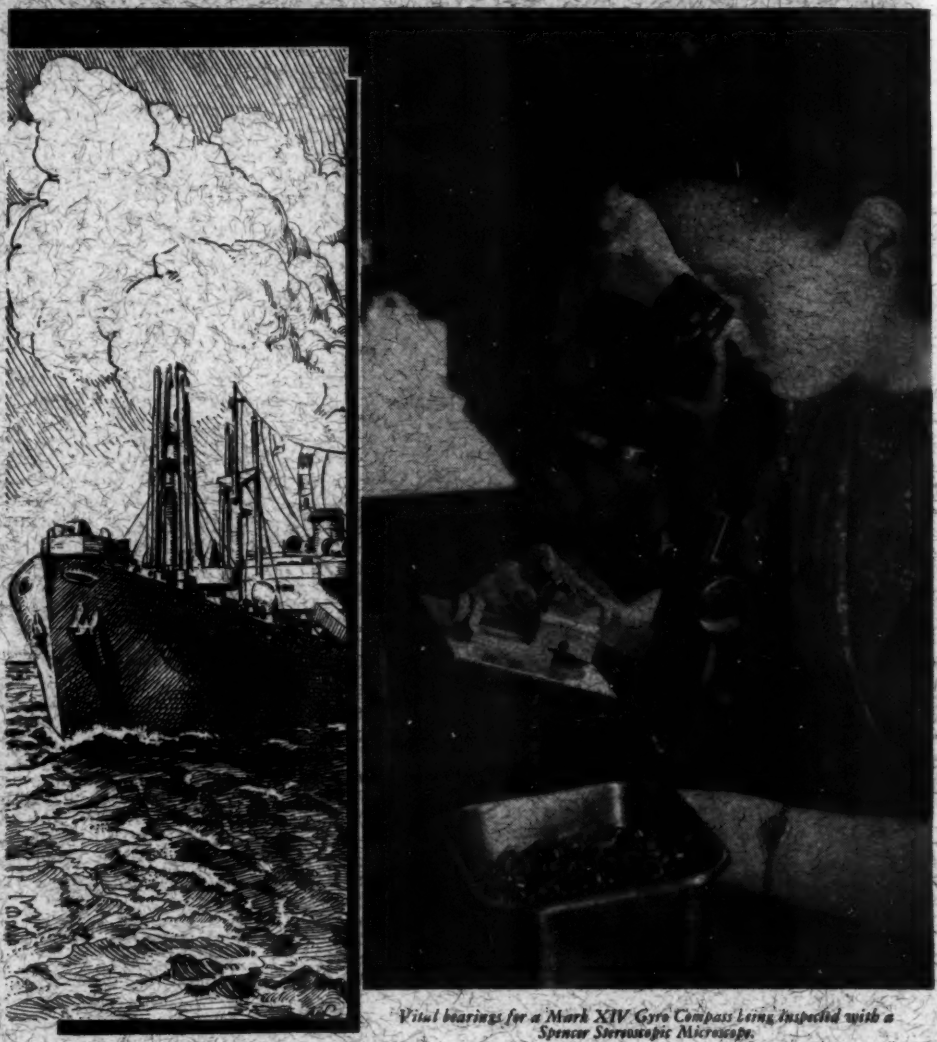

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